JOURNAL of the SOCIETY of MOTION PICTURE and TELEVISION ENGINEERS

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Decomposition of Film
Background Process Photography
Special Effects Photography
Increased Noise Reduction
Miniature Condenser Microphone
Magnetic Sound Conversion
Magnetic Tape Recording
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Television Cutting Techniques

By RUDY BRETZ

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Summary—**The techniques of motion picture cutting have in some measure found application in television cutting as well. Characteristics peculiar to the new field, however, have influenced the growth of new techniques. In this article the author outlines the basic principles of television cutting from the creative or production point of view. In a succeeding article he will discuss the equipment in use in television stations for the switching of picture signals.**

In motion pictures, a change from one scene to another is usually accomplished by a cut. The editor determines the exact point at which the change should occur, trims off the unnecessary portions from the end of the first scene and the beginning of the second, and then joins the two together with a splice. This process is called "cutting." To "cut" a film does not mean simply to reduce it in length by taking out unwanted portions. It is the whole process of putting a film together, choosing which shot shall follow which, determining the precise length of each and the exact frame on which each cut shall be made.

The cutter is the one who does the physical work of handling the film. The creative decisions are usually made by a "film editor," who may sometimes do his own cutting. Motion picture cutting is recognized as a vitally important aspect of the film art. It is a profession in itself. Some film makers have gone so far as to say that in the technique of cutting lies the entire process of creative film art.

In television, a change in the scene is made with an electric switch, not with the scissors and splicer. Strictly speaking, we should call it "switching" instead of cutting. But the word "cut" has come to mean an instantaneous change of scene; and, since that is what we produce by pushing buttons, it is still correct to call the process cutting. Both terms will be used hereafter: "cutting" when the creative aspects of the process are being considered, "switching" when the discussion is on the technical side.

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In end result, the process of cutting television is very similar to that of cutting motion pictures, but the method is entirely different. A film editor may take weeks to cut a show, deliberating over each decision. A television director has to do his job during the show itself. He must rely on fast thinking, quick reaction time, and thorough preparation. In some cases he relies on his script, or on his assistant, who follows the script. The sight of the television director excitedly calling shots ("Take Two! Take One!") has led some to think that shot calling is all there is to television directing. Some directors actually do forget to make full use of their cameras, because they are so occupied with just the problem of cutting.

In creative production a good director plans his cuts, just as he plans his camera shots: on paper. If he has had enough experience, he can visualize the effect of a cut, even between two shots which also exist only in his mind, or as thumbnail sketches on the margin of the script. He will not limit himself to what he has planned, however, once he has produced the shots with cameras and watched the effect of the cut on the master monitor. He may change the camera shots to improve the cut, or he may change the timing of the cut itself.

By far the greatest number of television shows, however, are produced with little or no rehearsal; and the cutting cannot be planned in advance. Even if camera shots are set in rehearsal, the cutting is very rarely the same on the final air show. This is because the timing of the cut or the choice of camera depends mainly on the performers. If they deviate from the rehearsed routine, or go through actions which have not been rehearsed at all, the director must be on his toes to adapt his cutting to their performance. This is called "off-the-cuff" shooting, "*ad lib*" cutting, or "winging" the show. The method of control-room operation makes a lot of difference in whether this kind of cutting can be successful.

METHODS OF CONTROL-ROOM PROCEDURE

1. The Switcher System

Under this system the director is in constant inter-phone connection with the cameramen. He is responsible for the placement and use of the cameras, and is considered in direct charge of the cameramen. He "calls his shots" to an engineer, whose function it is to punch the buttons which switch from camera to camera. This engineer is sometimes called the "switcher," sometimes the "technical director" (T.D.). This is the most common method in use today.

2. The Technical Director System

Under this system the director has no verbal contact with the cameramen. He will call shots to a technical director who punches the buttons as in the preceding case. The technical director under this system, however, is in charge of the cameramen and the use of the cameras, as well as all other studio facilities. He works with the cameramen as a team and with the director as co-worker. Sometimes the T.D. will take cuts himself especially if they have been established in rehearsal. Usually he will punch buttons only at the director's command. The director may talk to the studio during rehearsal over a loudspeaker, and he can talk to the floor manager over earphones. As far as I know this method is limited to the five NBC-owned stations across the country, to WABD in New York and WSB in Atlanta. It has been tried elsewhere and abandoned.

Proponents of this system see in it an analogy to the method of Hollywood production, in which each film has two directors, one of whom is the Director of Photography and is in charge of all technical aspects of the production, while the other carries the title of Director and is responsible for the dramatic action. Some directors, who have also worked under the switcher system, prefer this because it makes their work lighter. Relieved from having to think about cameras and cutting, they are able to do a better job with the directing of the actors.

One director, who has directed programs on many stations, says that working under the NBC system is like having a twin directing the program with you. During rehearsal much time can be saved. When in the course of rehearsal a stopping point is reached, the director can go out and fix the actors' errors and come back to the control room to find all the camera changes made and everything ready to go again. Of course this is predicated on the ability of the T.D. He must have almost as good a background as the director himself. He must be primarily a showman, not an engineer. Where this method is in use, however, the job of T.D. is always an engineering job. The T.D. must be in charge of the camera and control-room crew, and for this reason must be a superior engineer. Men who can fulfil all these requirements are rare, or cannot be found for the salaries that are offered.

The T.D. system breaks down when an inexperienced man is on the job, or when an *ad lib* show is attempted. I have watched a green director, a green T.D. and green cameramen attempt to use this

method, and the results were miserable. The director would give a camera order, and the T.D. would garble it a little in relaying it to the cameraman, since he had no clear idea of what was meant. Then the cameraman would do the wrong thing. "No! I didn't mean that!" the director would tell the T.D. "I meant so-and-so!" This was again relayed to the cameraman. This time the cameraman himself would make an error. When it was all finally straightened out and everyone knew what it was the director wanted, it would turn out to be something that couldn't be done anyway because of some technical factor which no one had anticipated.

During an *ad lib* show, camera and cutting instructions must be given very rapidly and acted upon immediately or action may be lost. Sudden instructions to the cameramen cannot originate in the director in these cases, since, by the time they are relayed through the T.D., the moment has passed. To be sure, the T.D. himself may wing the show; but he is acting then in the capacity of director, which very few T.D.'s are able to or would be allowed to do. A good T.D. could assist the director by keeping one step ahead of him. He could so engineer the cameras that the director would have a variety of shots to choose from in calling takes and one camera at least would always have a good shot, well framed, from the proper angle to show the action, and ready at the right time. There is some question, however, as to whether this could not be done just as well or more easily by the director himself. The general opinion is that for *ad lib* shows the T.D. system does not work. Since most television stations must do the *ad lib* type of production (and practically all remote pickups fall into this category), most stations have decided against this method.

3. The Director-Switching Method

In this method, the director not only talks to the cameramen but operates the switching system as well. Some of the smaller stations have adopted this method purely for reasons of economy, and because there was no local union jurisdiction over the job. Others have chosen it because they believe it to be the best method of control-room operation. The exact moment that a switch is made is very important, and a split second's delay can often mean the difference between a good and a bad cut. In baseball pickups, a bad cut is much worse than that: it is a lost play. A majority of the stations have adopted the director-switching system at least for baseball and other sports remotes. A few have carried the policy over into studio

operation. WCAU-TV and WPTZ in Philadelphia are good examples. Making a comparison with the T.D. system, they say at WPTZ, "It is easier to train a director to punch a few buttons than it is to teach an engineer showmanship."

This method of operation works out fairly well in small stations and on programs which are not too complicated. In the production of dramatic shows, however, it is advantageous to the director to be able to dispose of the burden of handling the dials and switches.

PRINCIPLES OF CUTTING

The principles of cutting that I shall outline here are the same that have governed film editing in all but the most esoteric types of films or film sequences. These are the techniques that achieve a "smooth cut" and assure a visual continuity. Good cutting, under this criterion, is unnoticeable. Two shots are joined in such a way that the audience is completely satisfied by the result and its attention can properly remain with the action, rather than being distracted by the method of production. Subject is more important than form in this type of production.

Basically, the responsibility of the television director is to satisfy the viewer. When something is going on and the director is making pictures of it, he must show it properly, or the viewer will be dissatisfied. He must show the viewer what he wants to see. Forty years of an ever-improving motion picture art has educated him to expect a lot. He wants close-ups on essential action and he wants them quickly, just as he is used to getting them in the films. He wants to look around and know where he is and he expects good orientation. Above all, he doesn't want to miss anything that happens and he doesn't want to be confused.

The director must show the viewer what he wants to see, when he wants to see it, and cause him no confusion in the process. If the television director can achieve even so much as this, he will be a good director. Fancy angles, subjective camera and montage cutting also have their place, but they can never substitute for the basic requirements.

Showing the viewer what he wants to see might better be classified under camera handling than under cutting. But showing it to him when he wants to see it is definitely a principle of cutting. The timing of the cut is perhaps the most important single thing about it, and the

one thing that is most likely to be a little off in television. Film editing procedures take account of the timing factor and usually include a "rough cut" stage where all the scenes are overlong. When the film is projected and studied in this condition, cuts can be more exactly timed. In television such a procedure is impossible. A long shot and a medium shot which are to be cut together exist side by side on two monitors. A switch between them is instantaneous and irrevocable.

Within a sequence of shots taking place in one scene, the actual length of an action cannot be changed. An actor crosses the room, and we cut to a close-up when he reaches the other side. In film editing there is a possibility of shortening the actual time of the cross. If the actor walks out of the frame on the first shot and into the frame on the second, the entire intervening time can be eliminated. This is known as "creating filmic time." In television we can condense time in this way only between sequences or by special devices, but not in the regular run of shooting. We are limited to actual time, since television is basically an art of actuality. The choice, by the director, of the best segment of this actuality, at the best time, is the process of artistic selection, which is a good part of what might be called the creative art of television.

Dependence on actual time, however, simplifies television cutting as compared to cutting film; there is no need to worry about matching of action. In film shooting, it is always a constant worry to be sure that the action is the same when you shoot a close-up as it was when you shot the medium-shot just before. If an actor sits down, he must do it at the same speed each time, hold the chair with the same hand, cross his legs in the same direction, etc., or joining the two pieces of film will be a great problem. Then, in film cutting, even when you have two shots with identical action in them, there is the problem of cutting between them, so that the action, which begins in one shot and ends in the other, will be smooth and continuous. There must not be any overlapping or anything missing. This also we are spared in television.

Cutting on Action

The principle of cutting on action is just as important in television as it is in films. There is nothing that will so disguise the fact that a cut has been made as a strong and positive action to carry across

from one shot to the next. The cut should be made during the action itself, not just before it, and not after it. As a director you must watch your monitors very closely, have the second camera ready, call the first half of your order, "Take . . .," and just at the moment of the move, call the camera number. If it is a short movement, like a dancer's leap, for instance, and there is any delay at all, the cut will come after the leap is over.

It is very important for the switcher or technical director who punches buttons to know ahead of time which camera is to be taken next. His reaction time is faster then. He has only to punch the button. He doesn't have to decide first which button to punch. KLAC-TV in Hollywood has established a rule requiring directors to call the camera number first, before they call the take. If they say, "Two. Take Two," it gives the technical director time to get ready, and a well-timed cut results. In spontaneous cutting, however, it is not always possible to anticipate sufficiently ahead of time. Many of the directors' orders at this studio sound more like "Twotaketwo," which is no great advantage, and just gives the director more to say.

The director's best method, I believe, is to give a "ready" cue whenever possible. This is appreciated also by the cameraman who is not so likely to be caught changing lenses or adjusting focus at the moment of the cut. "Ready Two" can be said almost automatically while you are watching the action on camera Two. Where the cut must be precise, a further "Take . . ." will keep the technical director poised. Then the number can be thrown very quickly, accompanied if desired by a hand signal, and the reaction is almost as fast as though the director himself pushed the button.

The moment of action is such a natural place to cut that it is possible to violate the other principles of good cutting and get away with it, as long as the cut is made on action. For instance, one principle, which I shall describe later, is concerned with keeping left and right straight in the viewer's mind. Whoever is looking or moving left in one shot should be looking or moving left in the next, if the action is to match at all. However, Don Hallman at WXYZ-TV covers wrestling with two cameras, which are on opposite sides of the ring. The purpose of this setup is that one camera can see what is hidden from the other. He has great problems in cutting, however. Whenever he switches cameras, the contestants change places on the screen. Hallman's method is to wait for a positive action before making his

switch. A definite action (and there are many such movements in wrestling) will leave no doubt or confusion in the mind of the audience as to which person is which.

Cutting on action is possible, however, only if the attention of the audience is definitely centered on the action through which you intend to bridge the two shots. If you start with a long shot which includes several actions, the audience is as likely to be watching one as another. If the shot, let us say, shows four football players warming up before a game by kicking punts, and the director should wish to cut to a close-up of one of them, he cannot do this on the action of the kick. There is a three-to-one chance that the viewer may not be watching the same player that the director is looking at. If the viewer's attention happens to be on the wrong player, the new shot will suddenly be upon him in the midst of an action. It would be best in this case to cut before the kick, so that the complete action would be included in the close-up shot, just as one would do in cutting to another scene, when matching of action is unnecessary.

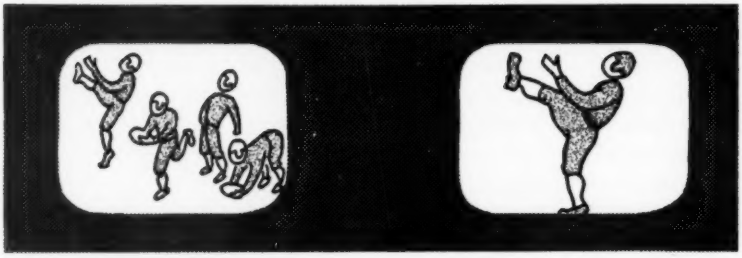

Figure 1

Cutting on Reaction

One of the most powerful motivations for a cut is to have someone in the picture look outside the frame. Immediately the audience wants to see what he is looking at. A shot of another subject—anything under the sun—is accepted, at least momentarily, by the eager viewer. The viewer has been shown what he wants to see. More than that, the director has contrived, by the device of having someone look, to make the viewer *want* to see the thing the director is going

to show him next. He can cut to almost anything at all and make a good cut. For a joke, he can even put in something ridiculous. If the shot is entirely impossible and incongruous, the viewer will laugh at himself for having accepted it, but only after a smooth and natural cut has been foisted on him.

This same general principle applies in the case of an actor pointing a camera or a gun. The audience wants to see what the actor is aiming at.

Such a device can be used to motivate a cut to a very big close-up, from a medium- or long-shot. Usually it is best not to make the change of shot too extreme. Long-shot to medium-shot, medium-shot to close-up, close-up to big close-up is the normal progression. But if a person picks up a picture or a letter or obviously concentrates his attention on a very small portion of the scene in front of him, a cut to that small area is perfectly motivated.

Cutting is often motivated when the audience wants to see someone's reaction to what has just been said or done. In the audience participation show, a contestant is blindfolded and put through some silly stunt. A shot of his wife's reaction to his asininity is completely motivated (provided she is reacting at all). In the dramatic show, when two people are in conversation, it is often desirable to cut to a close-up of the person who is not talking, in order to watch his reaction to what is being said. Standard procedure under other circumstances, when covering a conversation, is to show the person who is talking, at all times, and to cut back and forth on every speech. You have to show the viewer what he wants to see, and he is interested primarily in the source of sound. Noises off screen, the opening of a door, or a voice, will make the audience want to see where the sound is coming from.

The Cut-in or Intercut Shot

Sometimes during the course of an event or performance it may enrich the show to cut away from the event and interpose a shot of something else. A spectator reacting to a sports event, or not reacting, as the case may be, is a good example. The newsreels frequently intercut a close-up of screaming fans just after a good play or show a long-shot of the stands if the preceding action has not been too exciting. But in films this serves a practical purpose, which does not hold true in television.

An intercut shot in a film can be used to separate two shots that do not match and cannot be cut together. A smooth continuity results. Moreover, the film audience does not mind being taken away momentarily from the primary action, because it knows that the film editor has included the rest of the scene in the reel, and that it is not going to miss anything. The television viewer, on the other hand, feels no such certainty. He is afraid, while he is watching the frenzied fans jumping in the stands, that he is missing something going on down on the field. The same is true of audience participation shows, comedy shows, variety shows and many other kinds of spontaneous programs. If intercut shots are to be used at all, they must be used at a time when nothing of importance is likely to happen elsewhere, or they will not be what the viewer wants to see.

A dramatic show is much more akin to a film in this regard. The thing is built and presented as a whole. It is not segments of reality, and the audience has no fear of missing anything.

All of the cinematic techniques are applicable to television dramatic shows, if they can be physically accomplished at all. Intercutting of extraneous shots for purposes of contrast, irony, flashback, etc., can be accomplished as well in television as in the film medium. These techniques are analyzed in such books as Rudolf Arnheim's *Film*, Raymond Spottiswoode's *A Grammar of the Film* and Ernest Lindgren's *The Art of the Film*.

Length of Shot

Among people who don't know too much about the art of cutting, there is prevalent a misapprehension that a lot of cutting increases the tempo of a production. This is carried so far that statements like this have been heard: "There should be a cut at least every 20 seconds in order to keep audience interest." This is by no means always true. A shot should be as long as the proverbial piece of string. Tempo is not controlled only by the rate of cutting, except perhaps in newsreels or documentary films. For instance, in the newsreels or in the "March of Time," films which are built from a series of more or less disconnected shots, scenes of three or four seconds in length are standard. A shot containing action should be continued as long as necessary to complete the action, or cut as short as possible, one might rather say, without *losing* any of the action. "The True Glory," a war film made from thousands of stock shots taken by a great number of Signal Corps cameramen, was cut to a very rapid

pace. The shots were, straight through the film, less than two seconds in length. This resulted in a picture which was very hard to watch.

Cutting, in this type of film, does control tempo, because it controls the speed at which the film progresses from subject to subject. Television production, however, is not like this at all. Cutting, in television, is usually not from one subject to another, but from long-shot to medium-shot to close-up, etc., all on the same subject. The speed at which the actors in the play progress from action to action is what determines tempo. All the frantic cutting in the world can't speed up the show.

I remember once, as a young director, being given a sports interview show to direct. The master of ceremonies and the interviewee sat together on a sofa and talked. Here was my great opportunity to do a real production. I dollied the cameras in and out. I cut from one angle to another: big close-ups, high two-shots, timing each cut accurately with the phrasing of the conversation, building up what I thought must be a terrific pace. But I succeeded only in sweating up the camera crew and making it hard for the audience to relax and pay attention to the interview. The show remained nothing more than two people sitting on a sofa and talking.

What is the absolute minimum length of shot? is a question that is sometimes asked. Four frames of film are enough to give the film audience a glimpse of a subject; there are shots of this length in some of the montage sequences in Hollywood films. It is amazing how quickly the eye can take in a picture. Back in the Keystone Comedy days they found they could get a better laugh if they cut in close-ups of action. If the action was only a pie hitting a face, or a quick change of expression on a comedian's countenance, it was included in a few frames of film, and there was no need to run the shot even as long as one second to show what had happened.

Fast cutting is very rarely desirable in television, and hardly ever possible. For one thing, you run out of shots too fast. You have only two or three cameras, and you have to allow time between takes for the cameramen to line up new shots or you will be repeating yourself.

Furthermore, television doesn't call for the pace of the motion picture. The two media are different in this respect. Since the audience is watching reality in the case of television, it is content to let events take their own natural time. It is hard to imagine a group of people sitting through a two and a half hour film of a football game in the

way that they will watch a full-game telecast. As movie-goers, they are used to a condensation of time and a tempo of production which is purely filmic.

Cutting vs. Camera Movement

Since the film is a construction made out of shots spliced together, it is natural that the cut would be accepted as the normal thing. Television, on the other hand, is an electrical pickup of reality. The television camera makes pictures continuously, as long as it is turned on and the beam control is up. Theoretically, the long continuous shot is more natural to the television medium. Furthermore, a television show is much less a construction than it is reality itself. The television viewer feels toward the receiver as though it were a kind of window through which he can see distant events. The more real this view, the stronger his feeling. These theoretical considerations seem to indicate that cutting is something to be avoided in television.

Camera movement is, of course, the alternative. Instead of cutting to a closer shot, why not dolly in? Is it not better to use a Zoomar lens on a baseball game than to cut from camera to camera? By and large, this is true. Tony Bunzman, who directed at NBC before the war, did some very fine dramatic shows with only one camera. There are times, however, when the advantage of a cut over camera movement is very great. Several such advantages can be listed:

1. One practical consideration is time. It takes time to dolly in to a close-up, and back again. The action must slow down and wait for the camera. It is much better to cut to a close-up and cut away from it again in a matter of seconds, and get along with the show.

2. Rehearsal time is also involved. A dramatic show can be planned with a great deal of actor and camera movement, or it can be done by cutting between a series of static shots. A lot more rehearsal time is needed to produce a show with camera movement. The movement, the positions of the actors and the co-ordination of the cameras, all have to be carefully worked out and well rehearsed if they are to work at all. Simple cutting from one shot to another can be worked out in much less time.

3. Reaction shots, also, often cannot be made by panning or dollying the camera. When the viewer sees someone look at something, he wants to see immediately what the actor is looking at. The viewer is seldom content to wait through a long pan shot across unimportant background to see it.

4. Another consideration is the dramatic value of the cut itself. The sudden appearance of a new picture on the screen can be put to good use sometimes, entirely for its shock value. This is particularly possible if cuts have been used sparingly in the sequence just before. A sudden dramatic moment can be enhanced by sharp cuts. A cut is useful for punctuation, something that is more difficult to accomplish with camera movement.

Matching the Center of Interest

When a cut is made, the eye must quickly adjust itself to a new composition. The easier the readjustment, the less noticeable and the smoother is the cut. One factor which determines this smoothness is the relative position in the frame of the center of interest in each case. In the first shot in Fig. 2 the center of interest is the

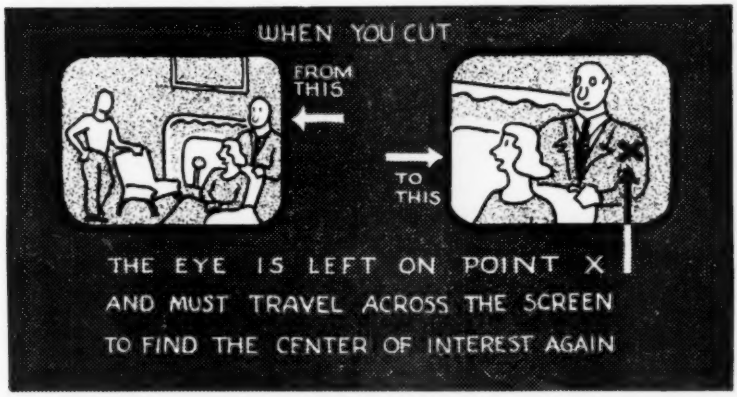
WHEN YOU CUT
FROM THIS
TO THIS
THE EYE IS LEFT ON POINT X
AND MUST TRAVEL ACROSS THE SCREEN
TO FIND THE CENTER OF INTEREST AGAIN

Figure 2

woman talking, in the lower right corner of the screen. If a cut is made to a close-up of the same subject, but composed so that the woman is then to the left of the screen, a readjustment of the eye is necessary. The eye remains focused on the lower right corner after the cut, with nothing particular to look at. It must find the center of interest again in its new position on the screen.

This is really a minor point in television, since there are usually so many other, more important things unaccomplished. Where greater perfection is desired, however, it is something to consider. An ex-

ample is in the pickup of sports. The smoothest possible cutting is necessary in covering sports because even a momentary confusion is enough to cause the viewer to lose track of a play, particularly in a fast game. It is about all you can hope for if each camera merely centers on the action. If each camera centers the ball, at the moment of the cut the ball will remain in the same place on the screen.

Cutting to the Audio

Sometimes, when all else fails, the phrasing of sounds will provide a natural place to cut. For instance, all else being equal, it is smoother to cut at the end of a sentence than in the middle of one. The phrasing of music forms a very compelling pattern for cutting, especially when the music plays an important role. The music is reinforced if the visual change follows the changes of tone color, chorus and verse. Clark Jones, one of the best directors in this field, is known for his accurate cutting in musical shows. His shots may be eight bars, four bars, sometimes only two bars in length, depending on the change in tone color of the music, and the cut is always made precisely on the beat, showing the new musician just as he begins to play. When tone-color changes every two bars, so do the cameras; when a vocalist sings 32 bars without a break, the camera rests quietly with the subject.

What Not to Do in Cutting

To the tyro director who has had little experience in the film or television media, I would direct the following words of caution:

1. Don't cut too much. You are likely to make the show harder to watch, or to irritate your audience. If you have time to work it out, camera movement or actor movement is smoother. Use the cut for dramatic punctuation or to get a shot on the air quickly. Don't go crazy with "brilliant" cutting unless you know what you are doing.

2. Don't cut blindly. Some directors seem to close their eyes and say, "Take Two." They are afraid to take their eyes off the master monitor. Keep looking back and forth, try to watch all the monitors at once. And look at the camera monitor before you call the take. You'll get fewer lens changes and out-of-focus shots on the air, if you do.

3. Don't cut from one shot to another one just like it. A cut from a two-shot to a two-shot adds nothing. To be sure, the second one is

from a different angle, but does it show the audience anything more?

Never let two cameras give you the same shot. Be sure that one of them changes lenses or repositions, otherwise it might as well not be out there. Sometimes a director gets stuck and has to cut between two identical shots, bad as such a cut may be. He may find, for example, that he has to release the camera which is on the air for some sudden need. He must cut to another camera. His only possibility is an identical shot on another camera, and he hasn't time to change it to something different. The viewer doesn't hear his excuses, however; all he sees is a bad cut.

The worst example I can remember of cutting between similar shots occurred on a musical program. In this case it was close-ups of a singer. There were three cameras: one presenting a full face of the girl, one a left profile the same size, and the third a right profile, also the same size. During the song the director changed shots often. There might have been a small reason for this because of the variety obtained by the change of angle, except that the performer was too smart for them. She was on to television. As soon as the camera changed, she spotted the red lights out of the corner of her eye and turned to face the new camera. Thus wherever the director shot from, he always got a full-face close-up. The singer continued to chase the cameras around for the rest of the number.

4. Don't cut to an extremely different angle. What constitutes too great a change in angle is hard to define. The main thing is to be sure that the subject is immediately recognizable and doesn't look like something else in the new shot. A shot from an angle that is so far different that an altogether different background is seen behind the subject will cause confusion. Sometimes a change of angle will make a great difference in the lighting. What is contrasty side-light from one angle may be flat front-light from another. The difference may be so great as to make the subject unrecognizable, at least for a moment. I have seen a profile shot of a news commentator cut in suddenly after we had been watching a full-face shot, with the result that the profile shot looked momentarily like someone else sitting across the room watching. The audience has no way of knowing that the new shot is taken from a different camera angle until they have seen the shot and comprehended it. The natural assumption is that it is taken from the same place, but looking in a different direction, just as an observer on the scene would turn and take in another view.

The problem of camera placement in the pickup of baseball and other sporting events is directly tied in with this. When an action takes place *between* two cameras, so that they see the subject from opposite sides, the direction of the action will be completely reversed when a cut is made. Nothing can be so utterly confusing. It is usually best to keep at least the main two or three cameras as close together as possible on most sports pickups.

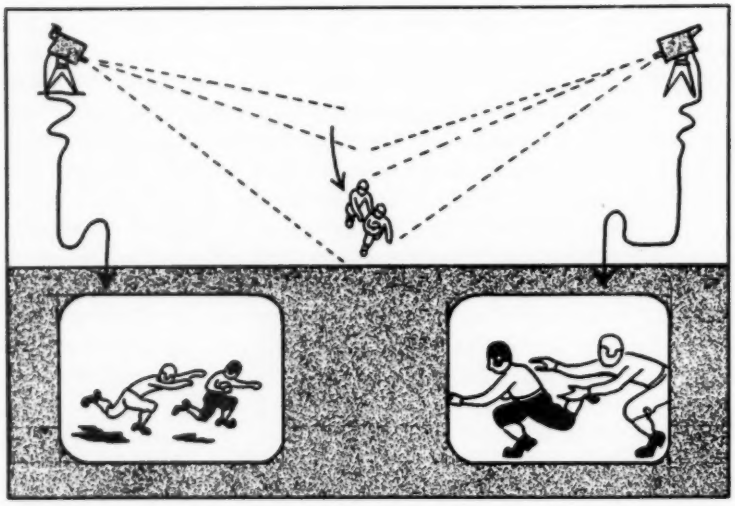

Figure 3

5. Don't cut on a pan. Don't cut from a camera that is panning to one that is static, or from a static camera to one that is panning. Try it once and you will see what I mean; it just can't be done. You *can* cut from pan to pan very nicely, providing they are both going in the same direction and at the same speed. When two cameras are following the same action, for example, the cut is usually quite smooth. At a football game, if both cameras center the ball as they follow an end run, it is perfectly possible to cut from medium-shot to close-up without the slightest confusion, since both cameras will be panning, and in the same direction.

6. Don't spoil exits. As far as the audience is concerned, once an actor has left the frame of the picture, he has made his exit. Don't rediscover him and exit him again in the background of the next shot.

ALTERNATIVES TO THE CUT

The Dissolve

The dissolve, lap dissolve, or cross-fade is the method of transition in which the first picture becomes steadily weaker while the second becomes stronger on the screen. It is really a fade-out simultaneous with a fade-in. If you stop the process at the mid-point you have a superimposure: each picture at half strength.

In films, the dissolve has been used with a certain connotation. By unwritten agreement, all film makers found it best to reserve the dissolve for a particular purpose. (The expense of having dissolves made assisted toward this end.) The meaning of a dissolve in films is transition through space and time. You dissolve between sequences: to a later time or to another place, or both. Dissolves within a sequence where no lapse of time is intended are rarely used in films, unless it may be by an amateur, fascinated with the dissolve mechanism on his camera, who dissolves between the long-shot of a garden and the close-up of a flower.

In television, unfortunately, a dissolve is no harder to do than a cut, and costs no more. Instead of taking another day to accomplish it, as we do in films (taking out the proper negatives, sending them out for opticals, then splicing back the dupe negatives into the reel), in television you simply turn a dial, or move a handle, as the case may be. With the Dumont equipment, as I shall explain in a later chapter, you punch the same button you ordinarily punch for a cut, and a dissolve is automatically effected. It is much too easy.

The result is a very free use of dissolves, often in places where a cut is really preferable. Dissolving within a sequence is often done on television, particularly in musical or variety shows. In such productions the director usually feels less confined to the motion picture tradition than he does when he is producing a dramatic show. The television dramatic show seems to follow the motion picture technique as closely as possible. The result is that in television we have a new connotation (or a loss of any connotation at all) for the dissolve.

Don't go dissolve-happy. Don't use a dissolve when a cut would be better. Don't use a dissolve when camera movement would be better.

The Fade-out and Fade-in

The motion picture connotation of the fade-out has been retained in television. The fade-out is sometimes called the "dissolve to

black" in television, because of the electronic means of effecting it with the dissolve control. It has a connotation of finality; it indicates an end to something. It may be used in place of a dissolve to link sequences together, where there is a greater change in time or place than is usually indicated by a dissolve. A dissolve retains continuity; a fade-out–fade-in breaks the sequence. It is not good, for instance, to fade in and fade out a series of titles, since the audience will think with each fade-out that they have seen the last of the series. Similarly, a play divided into a number of short scenes with fades between, will lack the unity it might have had if other devices were used.

The most dangerous aspect of using fade-outs in television is that the length of blank screen between fade-out and fade-in may be too long. Audience interest drops very rapidly when there is nothing on the screen. There may be exceptions to this rule: certainly when sound or music carries through, the wait is not so bad. However, the timing of the fade-out, the blank screen, and the fade-in should always be carefully planned and rehearsed. The shortest possible blank screen is particularly important when the fade-out comes at the end of a program or spot announcement. Every second's delay in bringing up the next picture means an increasing loss of audience. Dial turning on television is a much greater problem than radio ever had to contend with. Directors and technical directors have sometimes failed to look past the conclusion of one program and plan the initiation of the next. They wait until the final fade-out, heave a big sigh and then start hunting frantically through their schedule and routine sheets for the next move, while the screen remains patiently blank. This problem became so acute during the early months of operation at WPIX that we had to enforce a rule against any fade-outs at all. All transitions were to be made by dissolves.

There are ways of doing fade-outs in a program other than by simply turning down the gain, or dissolving to black. Fade-outs can be done with the lights on stage: the old familiar black-out. This is easier if the number happens to be lighted by one spot light, which is all that needs to be cut. The light can be moved off the subject, or the subject can move out of the beam of the light. If the motivation is very carefully planned, the camera can be panned off into a dark area, or dollied behind a dark object. This device was used by Olivier in "Hamlet." Another variation on this is to have an actor walk directly into the camera until he blocks out all the light. Which-

ever of these devices is used to effect the fade, it is usually good to use the same thing in reverse for the fade-in of the following scene.

An unusual use of the fade-out–fade-in was developed by Bert Gold at WICU when that station had only one studio camera. In order to change lenses, or to go from one stage to the next, the picture had to be quickly faded, the change made, and the picture faded in again. This procedure called for close co-ordination with the cameraman, but was a good adaptation to the situation. Ideally, assuming complete freedom of camera movement and an expert cameraman, it should be possible to cover everything with one lens (say a 90-mm) and keep the camera on continuously. The need to fade the camera out and avoid showing lens changes or portions of the studio beyond the actual sets is an inheritance from the production techniques of other media. In television we don't have to shun the backstage view, except when illusion and mood would be broken. The more reality, the more immediacy, the better the television in most cases.

Other Transitional Devices

1. The white fade. To the best of my knowledge this was first tried by Carl Beier and Bernie Brink at CBS-TV in 1941. It consists in fading out to white instead of to black. Naturally when it was first discovered, everyone went white-fade-happy; and for a while it was used more than anything else, at least by the directors at CBS. NBC and Dumont, who were also on the air at that time, did not seem to think it was that good.

Since the screen was constantly alight, it had less of a feeling of finality about it than a fade to black. The first time one saw it, however, one tended to feel that something had gone wrong and washed out the picture. We found good use for it between a series of titles (black letters on a white ground) so that only one camera and easel were necessary. It was a "fade white, pull the card, fade back in" routine. I haven't seen it used in recent years.

2. The de-focus transition. This requires a little co-ordination with the cameraman. Ready the next camera you are going to use by having the cameraman put it out of focus. Then at the right moment, crank the first camera out of focus, cut or dissolve, and bring the second picture up sharp. It requires a series of cues such as this, "Ready Two out-of-focus. One, de-focus. Dissolve to Two. Into focus, Two." It is assumed that the cameraman on camera One will

re-focus his camera again without being told, as soon as the effect is over. This device is particularly useful where a character in the play passes out or falls asleep just before the transition. The de-focus effect may also be combined with the fade-out for a greater transition through space or time. De-focus the camera, fade to black, then fade in to the next camera and focus up.

3. Visual confusion or interference. Almost anything which fuzzes up or confuses the picture can be used very nicely as an alternative to the dissolve. It is best, of course, if the first appearance of the effect is motivated in some way. Whatever is at hand will do: people walking in front of the camera, fire, smoke, water, etc., in front of the lens. Distortion glass or crinkled cellophane might be used in front of the lens, but these special transitions are rarely utilized because they take time to rehearse and execute properly. Remember that the transition device may arise directly from the special effects within the show. Anything which confuses the picture will find its use somewhere as a transitional effect.

4. Fade-cut and cut-fade. These are additional combinations of the foregoing transitions, which have been used on television and should be included in this listing. It is sometimes desirable to fade out one scene slowly, and then jump right into another scene, using the shock value of the cut. Or a cut to black is sometimes indicated, where you want a sudden ending to a scene, followed by a fade-in to the next. A rather particular case of this can be taken from Ted Mill's "Garroway at Large" show. At the end of his program the casual Garroway picked up a camera cable that was lying across the studio floor and explained that it was the coaxial cable carrying the program across the country. "It's about time to end the program now," he said glancing at his watch and picking up a small hatchet. "Now this might hurt a little," he said. He brought the hatchet down and the picture went black. Then came a fade-in on closing titles. In a moment, however, Garroway was back with his closing gag, holding the cable with a big bandage around it: "This program comes to you from Chicago, where we have very good connections."

5. The wipe. This is a cinematic technique in which the new picture starts as a small area and grows until it covers the entire screen. Filmic wipes can be made in a great variety of patterns, and new ones can easily be devised to suit special purposes. The simplest is the plain horizontal wipe, which is the only one that has been done elec-

tronically in television. Several types of simple wipes can be done optically by shutters and masks in front of the camera. These will be discussed under special effects in another chapter in this book. A wipe between titles, for instance, is not to be confused with a pull-off or slide-through, which is a bodily movement of the title in front of the camera. In the true wipe, two cameras are used (or two stages of an effects machine) and everything is stationary. The only thing that moves on the screen is the line of demarcation between the two pictures as the area of one grows larger and the other smaller.

No standard connotation was ever found for the wipe in motion pictures. It is very rarely used in dramatic films, finding its greatest value as a decorative device in industrial films, film commercials and the like, which depend on surface devices for their visual interest.

Methods of doing an electronic wipe have been in the design stage for years. They were first put into regular operation by NBC in 1949. The first use of the electronic wipe was to produce a split screen: with two ends of a telephone conversation shown at once. What was even more remarkable, an interviewer in New York was shown on the same screen as an interviewee in Washington. This will receive more complete treatment under electronic special effects in another chapter. All the switching systems at NBC-owned stations (their own design) now are equipped with a dial control for making a horizontal wipe. A wipe is sometimes used to lead into a split-screen effect. A man starts a telephone conversation. On the opposite side of the screen a wipe begins, then proceeds far enough to reveal the person at the other end of the line. When the call is over, the second picture wipes back out again.

(*A chapter on* Switching *is scheduled for next month.*)

Spontaneous Ignition of Decomposing Cellulose Nitrate Film

By JAMES W. CUMMINGS

National Archives and Record Service, Washington, D.C.

And ALVIN C. HUTTON and HOWARD SILFIN

National Bureau of Standards, Washington, D.C.

Summary—**Cellulose nitrate motion picture film in the advanced stages of decomposition is liable to ignite spontaneously. The danger of such ignition is reduced by inspecting stored film stocks and removing and destroying all decomposing film.**

During the abnormally hot summer of 1949, numerous fires involving cellulose nitrate motion picture films were reported in New York City and adjacent areas. These fires occurred in processing and reclamation plants and in standard film storage facilities. Losses resulting from these fires, other than those of real property, were severe, for the majority of the films destroyed were original negatives and master copies, some dating back to the "silent era." Due to the fact that these fires occurred either after working hours or on week ends, no casualties to personnel resulted, although some firemen were treated for smoke inhalation.

National Archives and Bureau of Standards engineers who investigated the fires could find no evidence that they were due to the negligence of personnel or the careless use of cigarettes or matches, but rather they appeared to have originated in the spontaneous ignition of deteriorated nitrate film. The summer of 1949 was one of the hottest recorded in the New York area, with the temperature reaching a maximum of 98 F. The mean high temperature for the months of June and July, 1949, was 83.1 F, as compared to a normal for the period of 79.3 F. The rainfall for the entire month of June was only 0.16 in. in contrast to the normal rainfall of 3.33 in. for the same period. The lack of rainfall and the unusually high temperatures of the period seemed to create ideal conditions for the development of spontaneous ignition in film stores.

A Contribution: Submitted February 9, 1950.

Prior to the investigation of these fires it was generally believed that nitrate film did not ignite spontaneously at temperatures likely to be encountered in a normal film vault. At the request of the National Archives, the Fire Protection Section of the National Bureau of Standards instituted an investigation to determine the possibility of spontaneous ignition as an inherent hazard in decomposing nitrate film. Samples in various stages of decomposition were supplied by the National Archives for the purpose of simulating conditions which may have prevailed at the fire locations. These samples were stored in a special chamber, the temperature of which was controlled and recorded. The films were packed in individual cans with each wrapped in mineral wool to retain the heat of the exothermic decomposition reaction. The ambient temperature in the chamber was initially 95 F and, at intervals, was increased by small increments. After 17 days of this treatment one 1,000-ft reel of film, initially in an advanced stage of deterioration, ignited; the ambient temperature in the chamber at the time was 106 F. Subsequently, with the ambient temperature at 120 F, another roll of film ignited.

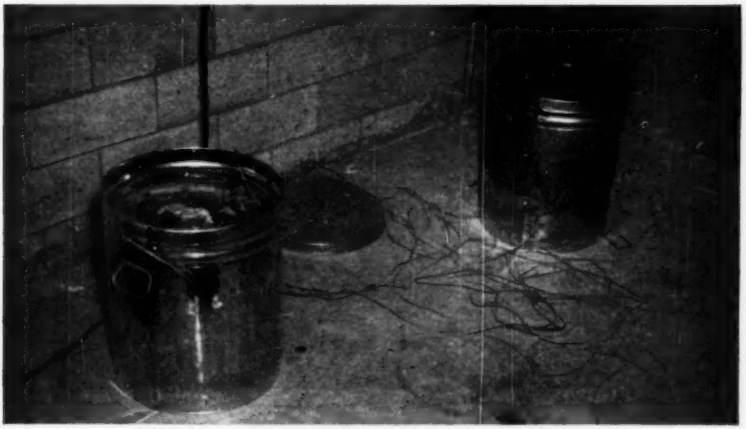

Fig. 1. Container in which reel of film was placed, showing thermocouple wires.

Tests made by the National Bureau of Standards have not yet been completed, but so far, some important conclusions can be drawn. Self-ignition temperature, which is dependent upon a number of factors, was not the same for any two samples. The lowest temperature

leading to ignition was 106 F. Because the number of samples investigated was small, it is doubtful whether this is the lowest temperature at which a reel of film can self-ignite. One reassuring aspect of the results of the tests to date is that no film in good condition has self-ignited.

Fig. 2. Reel of film which had spontaneously ignited during a test at the National Bureau of Standards.

DANGER NEXT SUMMER

At the moment, no one can predict what the weather conditions will be during the coming summer and it is quite possible that other regions may be confronted with abnormally high temperatures such as prevailed in the Atlantic Coastal Region during last year. This possibility offers the chance that there will be a recurrence of regrettable film fires. The hazard should not be underestimated for, even with abundant water supplies, cellulose nitrate fires are difficult to combat. Nitrate base film contains oxygen in chemical combination and does not need additional oxygen to sustain combustion. Furthermore, the fumes given off by its combustion are highly toxic and seriously hamper the fire fighters. They contain oxides of nitrogen which, if

inhaled, can be fatal. Shortage of municipal water supplies in many areas presents an acute control problem definitely requiring the constant maintenance of every safeguard.

METHODS OF FIRE PREVENTION

The results obtained in the Bureau of Standards tests indicate that good film does not self-ignite at ordinary storage temperatures. Therefore, the logical approach is to remove from storage all film showing signs of deterioration. Such film can readily be found by regu-

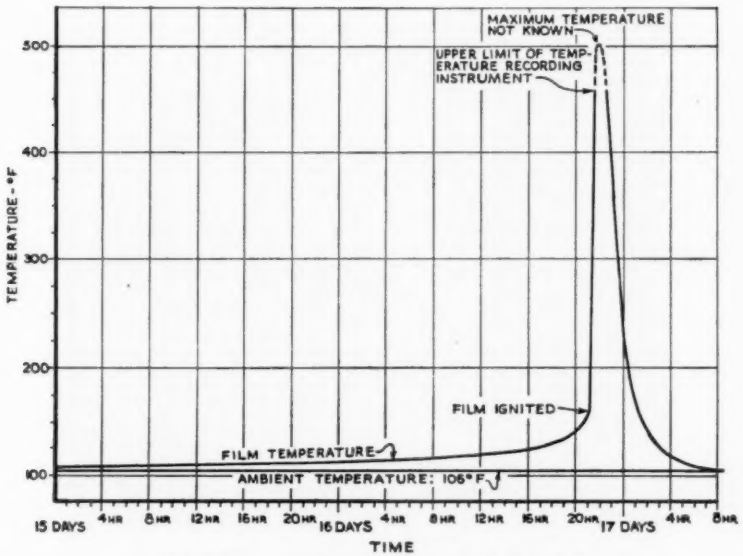

Fig. 3. Temperature during the critical period in which a film spontaneously ignited.

larly scheduled inspection of stored film stocks. Inspecting personnel should be trained to recognize decomposing film by appearance, with its condition classified according to the following categories. In the first stage of deterioration the photographic portion usually shows an amber discoloration with fading of the picture image. In the second stage, the emulsion becomes adhesive and the film convolutions tend to stick together during unrolling. Rolls of third-stage film have annular portions which are soft, contain gas bubbles, and emit a noxious odor easily recognizable. In the fourth stage of deterioration, the en-

tire film is soft, its convolutions welded into a single mass and frequently its surface is covered with a viscous froth. A strong noxious odor is given off, unmistakable to inspection personnel when once identified. In the fifth and final stage, the film mass degenerates partially or entirely into a brownish acrid powder.

Deteriorated film in the first and second stages is photographically reproducible. If the matter recorded is important, the film can be copied and the original disposed of. If the material is not valuable, the film should be disposed of at once. Adhesiveness prevailing in de-

Fig. 4. Sample of film in the third stage of decomposition.

teriorating film may cause the emulsion to become detached from the base while unrolling. This frequently can be prevented by slowly unrolling the film in a bath of carbon tetrachloride under precise laboratory control. This should be done only in adequately ventilated areas. In the third stage, only small portions of the film may be reproducible. The reproducible portions should be separated, if valuable, from the rest and copied. After reproduction, the entire original film should be immediately destroyed. In the fourth and fifth stages, film is photographically worthless and should be destroyed at once without further consideration.

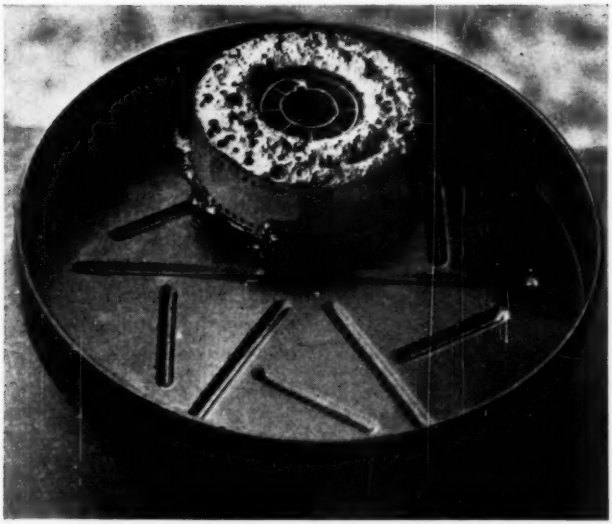

Fig. 5. Sample of film in the fourth stage of decomposition.

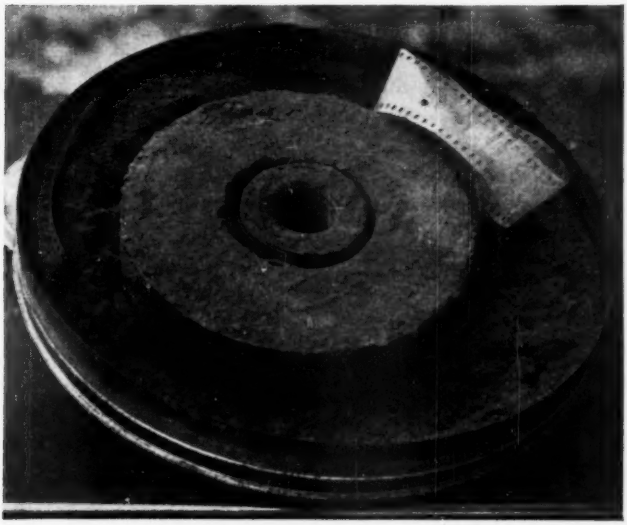

Fig. 6. Sample of film in the fifth stage of decomposition.

DISPOSAL OF DECOMPOSED FILM

Films of stages three, four, and five, designated for disposal, should be immediately submerged in water-filled drums. They should be carried in these drums to a remote, uninhabited area approved by fire authorities and destroyed by burning. The ground on which the film is to be burned should be free of brush, grass, leaves, and combustible litter. Burning should be confined to batches of not more than 25 lb, as the heat from the burning of large amounts of film creates a strong updraft which may bear fragments of burning film considerable distances to endanger neighboring properties. Under no circumstances should films be burned in an inhabited area or within a building. The rapid production of gases by burning film makes it extremely dangerous, particularly if burned in a furnace or confined space. During test fires in a well vented vault, engineers of the Interagency Advisory Committee for Nitrate Film Vault Tests have recorded pressures as high as 18 psi. It is readily understandable that no ordinary furnace structure could withstand this pressure; its breeching would fail and fill the furnace room with flames and poisonous gases.

PROTECTION OF PERSONNEL DURING INSPECTION

It is quite possible in the initial inspection that a relatively high proportion of film in advanced stages of decomposition may be found. The opening of cans containing this film may liberate quantities of noxious gases into the working area. Personnel exposed to them may experience nausea, headache, and other unpleasant symptoms if the ventilation is inadequate. It is, therefore, recommended that the personnel working on old film inspection be given ten-minute rest periods each hour in the outer air.

If we are to enjoy freedom from film fires during the coming summer, a comprehensive program of film inspection should begin now so that the task may be completed before the onset of hot weather. Since film is constantly subject to decomposition, inspection should be repeated annually, preferably in the spring. Only by such procedure can we avoid the insidious menace to life and property hidden in deteriorating motion picture film. Particular attention should be given to film of unknown quality or of obscure origin.

Sensitometric Aspects of Background Process Photography

By HERBERT MEYER

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Summary—**The composite negative obtained by photographing action against a rear projected background is a combination of an original negative with a dupe negative. An analysis by sensitometric methods of the gradational distortions thereby introduced has been attempted, the results of which are discussed in this paper.**

The advantages of background process photography over straight production technique consist generally in savings in location costs and in permitting a convincing picturization of supernatural effects. The same is true of a number of other photographic effect methods, all classified under composite photography, of which different types of matte processes are examples. A singular point which background process photography can claim as one of its distinguishing features is that the composite effect of background and foreground can be observed and evaluated prior to and during the actual photographing of the composite scene. As it presently stands, background process photography is but a small fraction of general motion picture production due to yet unsolved technical deficiencies and also on account of a somewhat reputed unpredictability of results. The combined advantages offered by this process are so obvious and substantial that its increased application seems highly desirable.

An investigation of the problems limiting the usefulness of background process photography in motion picture production has become one of the major projects of the Motion Picture Research Council. This rather basic study has not yet substantially advanced past the required preliminary work of evaluating available literature and technical knowledge represented by a store of practical experience in the studio transparency departments. This paper, therefore, is primarily confined to an analysis of some of the factors controlling the pictorial quality of the final composite obtainable with present methods. Such an analysis may contribute to the development of better meth-

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ods and equipment which eventually should make use of all the potential aspects expected of this process.

In parallel to the historic development of other phases of photography, background process technique has advanced, so far, on a purely empirical basis to a remarkable degree of performance. To develop this technique to greater efficiency, dependability and standard of quality, it becomes necessary to give it a clear and precise theoretical foundation.

Our discussion here is confined to black-and-white technique. It is further limited to the consideration of gradational requirements and problems of background process photography. This, therefore, excludes a treatment of such factors as definition, resolving power, graininess, etc., which are, of course, of vital importance in relation to the quality of the final pictorial reproduction.

BASIC PROBLEMS CONCERNING GRADATIONAL DISTORTIONS

An analysis of the possible sources of gradational distortions reveals three major causes:

1. Duplicating Distortions

This type of degradation is an inherent property of any duplicating process, bringing about a shortening of the straight line part of the characteristic curve. It may, therefore, affect gradational qualities of the background image reproduced in the final composite negative or print and will do so equally over its total area. Duplicating technique in straight printing as performed in processing plants enjoys a relatively comfortable latitude in the variation of density levels and gamma values of the intermediate print and of the dupe negative to keep gradational distortions in the dupe positive to a minimum. Background process photography, however, is restricted to a much greater extent principally by the fact that the processing of a composite can give consideration only to an optimum gradation of one part of the composite. This means invariably favoring the gradation of the original foregound action negative.

2. Distortions Affecting Different Background Image Areas

This type of disturbance is evident in density and contrast variations between the central image areas and off-center areas of the background component. They are caused by various factors, not easily isolated for the determination of each one's specific contribu-

tion. Individually and in combination they reduce the image-forming illumination incident on the film progressively with increasing angles.

3. Distortions Caused by Flare

Flare is non-image-forming illumination incident upon the film during its exposure in the camera. If present in sufficient intensity it will cause degrading of contrast and brightness range. The most common source of flare encountered in background process photography is "leak" light reflected from foreground objects onto the process screen. Other causes, however, are suspected of contributing substantially to this type of degradation.

COMPARATIVE IMPORTANCE OF GRADATIONAL DISTORTIONS IN COMPOSITE PHOTOGRAPHY

Ideal photographic reproduction of the projected background image requires by theoretical postulation linear density-brightness characteristics and an effective slope or gamma equal to unity. That this condition is not fulfilled in practice would, within reason, be just as acceptable as the common degradations in production release prints which probably never have straight line characteristics from clearest high light to deepest shadow. The adaptability of our aesthetic faculties apparently tolerates considerable deviations. However, as equally known from experience with other sensual observations, critical judgment becomes immediately acute in case a basis for a direct comparison of two even slightly different reproductions is presented to the eye. This is the case with composite prints in which the gradation of the foreground portion varies from that of the background portion.

BASIC ELEMENTS OF BACKGROUND PROCESS TECHNIQUE

A brief outline of the principles of background process photography as practiced in studios is given here as an introduction to the later treatment of its gradational problems.

The original background negatives are usually photographed on locations selected for this purpose, in which case the use of a panchromatic, fine grain emulsion type is generally adopted. Sometimes, stock shots of older date and not originally intended to serve as background negatives have to be used. In either case, a print is made, normally in contact, of such negatives which becomes known

as the "process plate." The positive stock used for making this print is in most instances regular release print emulsion type with a normal positive gamma. A special fine grain print stock with considerably lower gamma characteristics is also used. The process plate is projected in a special background projector onto a translucent screen. The rear projected image is photographed together with the action in the foreground by a standard black-and-white camera.

Fig. 1. Optical test arrangement (schematic).

Figure 1 is a schematic illustration of the optical test arrangement used in our experiments in investigating small process screen samples of different makes. An explanatory guide to the letter symbols used follows:

a Projector film gate
ab Focal length of projector lens = 5 in.
c 8 × 10 in. screen
ck Horizontal screen dimension = 10 in.
bm Distance between screen *c* center and projector lens = 3 ft $10^{1}/_{8}$ in.
mg Distance between screen *c* center and camera lens = 1 ft $8^{35}/_{64}$ in.
gh Focal length of camera lens = 2 in.
h Camera film gate
d 30 × 40 in. screen
dl Horizontal screen dimension = 40 in.
m'b Distance between screen *d* center and projector lens = 15 ft $4^{1}/_{2}$ in.
m'e Distance between screen *d* center and camera lens = 6 ft 10 in.
ef Focal length of camera lens = 2 in.
f Camera film gate

This arrangement was designed in exact correlation to the system commonly used in studio technique. Naturally, the figures for the distance between screen and projector and equally between screen and camera will increase proportionately with the size of the process screen employed. The projector and camera half-angles used in this illustration are co-ordinated to the focal length and aperture of the projector lens and of the camera lens respectively:

Projector half-angle, vertical:	4°	Camera half-angle, vertical:	9°
Projector half-angle, horizontal:	5.5°	Camera half-angle, horizontal:	$12^{1}/_{2}$°
Projector half-angle, diagonal:	7°	Camera half-angle, diagonal:	$15^{1}/_{4}$°

Use of a 5-in. projection lens and a 2-in. camera lens is representative of the most severe conditions under which background process pho-

tography is normally practiced. Wherever possible, lenses of greater focal length are employed to keep projection and camera angles as small as possible.

The gradational distortions to be discussed may be inherent in the "dupe negative"* alone or also in the process plate, both being the photographic media involved. The transmission characteristics of the process screen are all-important as factors influencing the gradational properties of the dupe negative. It therefore seems practical to treat briefly the photographic characteristics of the process plate separately and also to give special attention to the physical characteristics of diffusely transmitting objects in the form of the presently used translucent background screens.

PROCESS PLATE CHARACTERISTICS

Figure 2 shows the gradational characteristics of a sensitometric negative strip and of a contact print made from this negative. Ex-

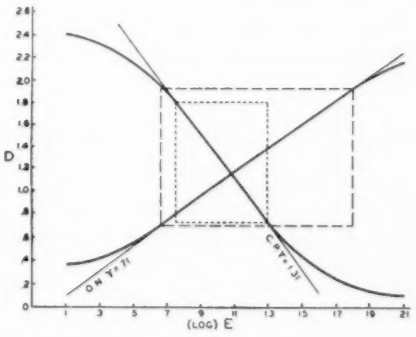

Fig. 2.

Intensity scale (factor $\sqrt{2}$)
Original Negative (O.N.)
Contact Print (C.P.)
Negative density range (str. line), 1.22
Print density range (str. line), 1.08
Negative exposure latitude (str. line), 1:56
Print exposure latitude (str. line), 1:7

posure and processing for both original negative and contact print were closely matched to conditions which govern the making of process plates.

It will be noted that the linear portion of the printed curve is relatively short, being terminated at the lower densities by the characteristic curvature of the positive material, and at the higher densities by the inherent curvature of the negative material.

The over-all gamma value of 1.31 for the print is considerably above the postulated value of unity. This may be necessary for two reasons,

* By "dupe negative," as used from here on, is meant the rephotographed negative of the projected background plate. "Dupe print" signifies contact print from "dupe negative."

one of which is to obtain an over-all contrast close to unity, the other to compensate for contrast reducing factors encountered in projecting and rephotographing the process plate from the process screen. This would mean that to obtain an effective contrast value of unity, the process plate has to be developed to an over-all gamma of 1.31.

From the graphs it may further be concluded that an increase in print exposure which would shift the position of the print curve to the right should result in an expansion of its linear part, while a decrease in exposure will cause it to compress further. This would indicate that heavy prints are preferable for process plates. Insufficient projection illumination, however, limits the use of high density prints in many practical setups.

Process Screen Characteristics

The background process screens used at present are translucent media to be classified as imperfect diffusers.

The brightness or luminous intensity distribution over the area of such a screen type differs widely from that of a perfect diffuser that follows the simple cosine law of emission:

$$I(\theta) = I_0 \times \text{Cosine } \theta,$$

where, I_0 = Candlepower of the surface normal to itself ($\theta = 0$)
$I(\theta)$ = Candlepower at an angle θ from the normal.

An illustration[1] of the difference in transmission characteristics for various diffusing materials in comparison to the cosine function of a perfect diffuser is given in Fig. 3.

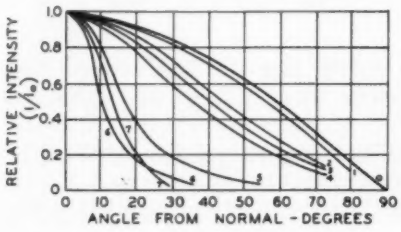

Fig. 3. Transmission characteristics of glasses.
0, Cosine curve
1, Solid opal glass depolished
2, Flashed opal glass, acid etched
3, Flashed opal glass, natural
4, Flashed opal glass, sandblasted
5, Clear glass, both faces sandblasted
6, Clear glass, one face sandblasted
7, Clear glass, one face acid etched

The rapid fall-off with increasing angle θ typical of imperfect diffusers is the main cause of the poor brightness distribution of presently available process screens. Unfortunately, the closer the translucent medium approaches the characteristics of a perfect diffuser,

the lower, in general, will be its relative transmission. In other words, gain in wide angle brightness distribution is accompanied by a loss in relative transmission or an increase in opacity. Figure 4 illustrates this dependence between transmission I_θ and $I(\theta)$ at a fixed angle of $\theta = 10°$ for several brands of commercial glass luminants with widely varying diffusing characteristics.

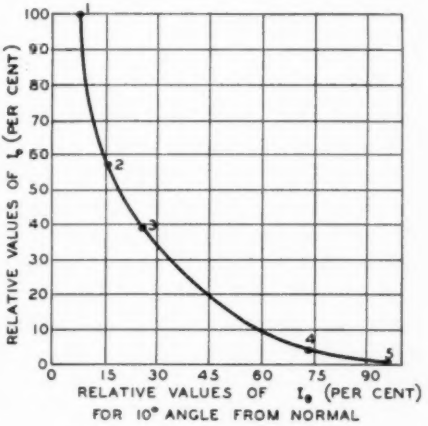

Fig. 4.
1, Factrolite
2, Tapestry
3, Maze
4, Sandblasted
5, Flashed opal

The angles encountered under practical conditions in 35-mm background process photography are within 15° for the projector side and 30° for the camera. The extreme angles stated are, however, quite frequently used of necessity. In some cases these angles may be still enlarged by the use of shorter focal length objectives, particularly for projection, when space limitations may leave no other choice.

The process screen type in use at present consists of a transparent cellulose acetate sheet which is sprayed on one or both surfaces with a layer of zinc stearate suspended in a solution of cellulose acetate. These layers serve as the diffusing medium which is, of course, needed to stop the projected image on the screen and make it visible and reproducible by photography. Each screen is handmade, and uniformity of transmission characteristics over the total area and from one screen to the other is therefore practically impossible to attain. The surfacing is accomplished by hand spray techniques which cannot assure even thickness of the coatings. The problem of uniformity becomes obviously more serious the larger the screen size. The transmission factor for $\theta = 0$ is determined in studio practice by simple comparative photometric readings of the amount of incident and transmitted light and serves as an indicator of the "speed" of the screen. Transmission readings made on a considerable number of screens at zero angle indicate that the luminous intensity of studio

screens varies in the range of from 55 to 70 per cent of the intensity incident upon the screen. The transmission characteristics determined by light meter readings are usually checked by means of a photographic density test. Such transmission readings serve in practice for guidance in arriving at a proper balance between level of screen brightness and foreground illumination. They are apt, however, to lead to erroneous calculations since they do not differentiate between specular and diffused transmission, and may also include light rays which do not reach the camera lens.

The present limitations in maximum light output of the background projector light source and optics make it necessary to increase the transmission of screens in direct proportion to their size, which the screen maker attempts by varying his spraying technique. Since it is desirable for various reasons to keep the light output of the projector constant, it is common practice to use denser process plates for smaller screen sizes. This means that for small screens with a relatively short throw, process plates of comparatively high density and low gamma are used, while for large screens and long throws, prints of relatively low density and high gamma are preferred. The over-all contrast of such different print types does not, of course, necessarily change by this procedure.

The transmission and light scattering characteristics of translucent screens have a large and multiple influence on the gradational characteristics of the composite photograph that is the end product of the background projection process. As it stands at present, practically nothing has been done toward a quantitative evaluation of these factors, with methods taking into specific consideration this field of background process photography. Much of the data available from literature on the subject of scattering of light[2] can be directly or indirectly utilized to great advantage in placing background process photography on a more efficient and reliable basis.

In addition, however, an extensive experimental investigation of materials and methods potentially suitable for making improved screens is indicated. Since the complexity of transmission characteristics of imperfectly diffusing media prevents the application of a clear mathematical treatment and since an additional photographic phase contributes to these difficulties, it seems fairly certain that direct practical experimentation studying size, refracting index, opacity, shape, distribution and other factors on a great number of materials will become unavoidable.

Practical experience in background process photography has, of course, established the validity of certain fundamentals which serve at present as rather general guides for screen makers and screen users. One of these, for instance, is the well-known observation that increase in diffusion decreases definition and contrast.

EXPERIMENTAL PART

1. Sensitometric Investigation of Typical Studio Procedure

The original sensitometric negative strip and print referred to earlier and shown in Fig. 2 were produced for this experiment in the following manner. A studio 35-mm motion picture camera with single frame exposure device was aligned on an optical bench with a point light source as a photographic target. Single frame exposures were made in succession with full aperture and at a constant speed of $\frac{1}{48}$ sec. The distance of the light source from the camera was increased by precalculated values to result in exposures with intensities decreasing by factor $\sqrt{2}$. The negative film type used was Eastman background emulsion. Processing by machine development was performed by Pathé Film Laboratories with instructions to develop to a customary negative gamma of 0.71. The developed negative was printed in contact onto Eastman Positive 1302 film and the resulting print developed for a control gamma of 2.15.

This print of an intensity scale negative strip was projected and rephotographed in regular background process procedure on a stage of the Universal-International Studios, together with pictorial process plates, and therefore is representative of the technique as presently practiced. The only exception to actual production conditions in background process photography consisted of omitting the inclusion of flare light from front illumination. The print was projected by a Mitchell background projector with a lens of 5-in. focal length onto a 9×12 ft process screen of the Sanders type from a distance permitting the projected image to fill the screen area.

The screen image was rephotographed by a standard 35-mm camera with a lens of 2-in. focal length and an aperture ratio of $f/4$. The camera was aligned with the projector and the center of the screen. The maximum off-axis angle formed by the projector was 7°, that formed by the camera was 15°. The resulting dupe negative was processed by machine development to a normal negative action control gamma of 0.67. A contact print from this negative was made

onto Eastman Positive Type 1302 on Light 11 and processed to a positive control gamma of 2.15. Figures 5 and 6 respectively show the density-log exposure graphs corresponding to both dupe negative and dupe print. Each of these figures depicts curves numbered from 1 to 4 which were obtained from density readings corresponding to various angles of illumination incident upon the film during exposure in the camera. It is quite apparent that for extreme off-axis image details, not merely a reduction in negative densities and a corresponding increase in print densities takes place, but also a pronounced change in curve shape and gamma compared with a curve constructed from the density readings of the image center.

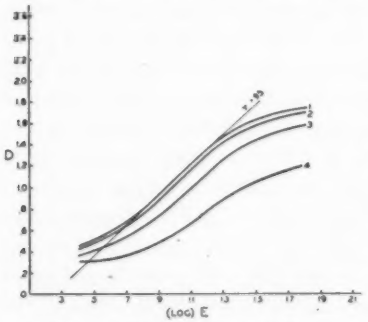

Fig. 5. Studio dupe negative.
1, Center readings
2, 5° angle off center readings

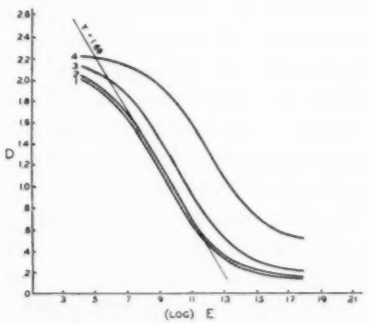

Fig. 6. Studio dupe print.
3, 10° angle off center readings
4, 15° angle off center readings

The progressive decrease in image-forming illumination on the film with increasing angles of incidence, which in turn resulted in the gradational differences shown in the above example, is mainly caused by the brightness fall-off characteristics of the process screen used.

The making of the process plate could not involve major off-axis distortions since in exposing the original negative the object was located on the optical axis so that vignetting and barrel effects as well as cosine^4 factor did not vary the image-forming illumination to any appreciable extent.

The background projector optics in this instance are adjusted to give a practically flat field for a half angle of 7°, and light meter readings of the radiation incident upon the screen did not vary more than 5 per cent from center to corner.

In rephotographing the projected image, stop $f/4$ was used which at least eliminates vignetting and barrel effects.

2. Sensitometric Testing of Different Types and Makes of Process Screens

A number of screen samples secured from three local fabricators were tested sensitometrically to determine and compare the influence of their transmission characteristics upon the gradational properties of photographic reproductions made in background process procedure. The test arrangement was similar to the one described and illustrated in Fig. 1. For the sake of simplicity and economy, and to obtain reproducible results in check tests, the following deviations from studio procedure seemed permissible.

As a projector, a factory-pretested Kodaslide still projector was used with an $f/2.3$ coated Ektar lens of 5-in. focal length. The illumination consisted of a 500-watt incandescent lamp operated at a voltage of 115 volts d-c which was carefully maintained throughout the tests.

The screen samples were uniformly kept to an 8 × 10 in. image area.

To obtain the process plate for this test, an 8 × 10 in. paper print of a step-wedge with six progressively increasing densities was photographed with a Contax camera on Eastman Background X type film and this negative developed to a gamma of approximate unity. The exposure was adjusted in such a way that the darkest field of the original step chart reproduced on the film with an approximate density of 0.40, the lightest field with an approximate density of 1.6 so that part of the film record registered on the lower curved portion of the characteristic curve of the film material. The image dimensions of the step-wedge reproduced on this film covered an area of only .25 × .06 in. in the center of the Contax picture frame. This frame was masked down to one-half standard 35-mm background projector aperture and projected in the Kodaslide projector onto the different 8 × 10 in. screen samples. At a distance of 69.5 in. between screen and projector, the screen image of the wedge extended lengthwise to the horizontal edges of the 8 × 10 in. screen. All stray light was masked off. This arrangement permitted projection with a maximum of central rays. The screen image was rephotographed from the back with an 8 × 10 in. view camera using an Ektar lens with 12-in. focal length and a 4 × 5 in. back. The film type selected for this purpose was Panatomic Cut Film. The film records were developed to a control gamma of 0.70. Exposure was kept constant for all tests and adjusted to the medium brightness level of all screens.

In rephotographing the projected screen images the camera was placed in two positions as follows:

A. Camera aligned with screen center and optical axis of projector. Distance between camera and screen center, 20 in. Placement of screen surface normal to optical axis of projector.

B. Camera moved parallel to screen with lens focused on center of screen until angle of 12½° between optical axis of camera lens and normal to screen was formed. Distance between camera and screen center, 21.5 in. Lens refocused for this distance. Placement of screen surface normal to optical axis of projector.

While this arrangement contains a number of unknown factors and does not permit a quantitative evaluation of the results, it was felt adequate in providing reliable comparative information which was the primary aim of this test.

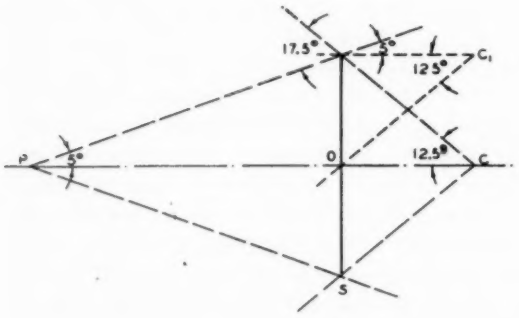

Fig. 7. (Not to scale.)

Figure 7 is a schematic illustration (angles not drawn to scale) of these two setups wherein C depicts camera position A, and C_1 camera position B. In both instances the optical axis of the camera lens meets the optical axis of the projector lens at the center O of the screen S.

The B-shot permits evaluation of transmission fall-off for a 12½° angle, characteristic of each screen. The arrangement was chosen to minimize factors causing additional brightness fall-off due to the projector optics employed. Naturally a slide projector of the type used does not give a similarly flat field as a specially corrected studio projector.

The step densities of each film record were read and the readings applied to construct density exposure curves. Since the factor of exposure progression was not known, the exposure scale is entirely arbitrary.

Table I lists for each screen and each camera setup the gamma readings and the density values of Step 1 (lowest density), Step 4 (medium density), and Step 6 (highest density). The gamma readings have, of course, no quantitative values. They permit, however, a comparative evaluation of the influence of each screen on contrast.

TABLE I

Screen Type	Relative Gamma Readings		Density 1st Step		Density 4th Step		Density 6th Step	
	A	B	A	B	A	B	A	B
1. Double*	1.60	1.61	.50	.42	1.16	1.05	1.90	1.82
2. Double	1.25	1.27	.44	.32	.95	.76	1.60	1.32
3. Double	1.46	1.45	.60	.43	1.19	.95	1.80	1.50
4. Double	1.48	1.40	.71	.45	1.31	.95	1.88	1.50
5. Single*	1.36	1.36	.74	.44	1.30	.85	1.88	1.44
6. Double	1.33	1.18	.48	.29	1.01	.64	1.65	1.17
7. Single	1.31	1.13	.62	.40	1.18	.82	1.70	1.32
8. Double	1.46	1.39	.44	.40	.96	.85	1.56	1.50
9. Double	1.42	1.50	.60	.45	1.17	.92	1.78	1.52
10. Double	1.22	1.33	.95	.80	1.35	1.15	1.84	1.80
11. Double	1.49	1.48	.58	.43	1.17	.97	1.80	1.58

* Double = double surfaced; Single = single surfaced.

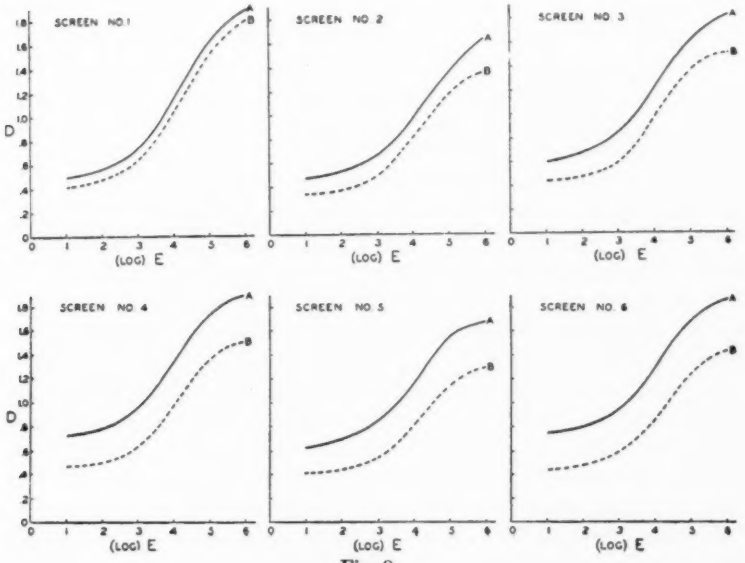

Fig. 8.

Figure 8 shows graphically these density curves for six selected screen types corresponding to Screens No. 1 to 6 of Table I. The solid line curves are constructed from densities obtained with A-shots (camera on optical center). The dotted line curves were plotted from densities obtained with B-shots (camera 12½° angular position). As will be noticed, the six selected screen types are progressively worse in fall-off characteristics.

In studying and analyzing the data contained in Table I, a clear relation between fall-off characteristics and relative transmission of the screens could not be established, nor was it possible to find a simple function of contrast in relation to relative transmission. This result is rather disappointing and emphasizes the complexity of factors under which background process photography has to be practiced at present. The irregularities observed, however, make it practically certain, in an indirect way, that more efficient screens can be constructed, that is, screens with optimum relative transmission (speed) and still relatively favorable angular fall-off characteristics.

CONCLUSIONS

The tests described in this paper were primarily selected out of a rather large series of similar tests performed in the course of this project, to exemplify the type of studies that have so far been undertaken. They further illustrate the problems that have been encountered and are expected to be faced in continuation of this work. Finally, they indicate the manifold factors and phases that are left for further experimentation and analysis.

While improvements of present type process screens and process technique appear entirely feasible, they may not lead to ultimately satisfactory results unless the complications and limitations of imperfectly diffusing screens are eliminated. This indicates a search for different types of projection screens which, while not included in the present discussion, is also under continuous consideration by the Research Council.

At this stage it is too early to make any suggestions or predictions concerning the development of basically new process screens and techniques. An investigation into the potential application of directional screens has been undertaken as part of our general project. However, the large size screens demanded for motion picture production work and the trend of making increased use of camera movement in front of the projected background present severe diffi-

culties and limitations in the manufacture and use of directional screens.

ACKNOWLEDGMENTS

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A Motion Repeating System For Special Effect Photography

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Summary—**This is a motion reproducing system for use in "special effect shots" (multiple exposures, matte paintings, pan and tilt traveling matte shots, etc.) which permits the change of a camera position and adjustment while photographing a scene. Then, with the film rewound to the original starting point, a second exposure is made on the same film of a second scene, duplicating the relation of camera position and adjustments to the film movement which existed while photographing the first scene. This is done with sufficient accuracy to match matte lines in any of the standard double-exposure or other similar effect shots.**

With modern studio equipment the camera is free to move about, follow the action, and graphically and pleasingly describe the scenery and tell a story. But all this freedom of camera movement does not help the makers of special photographic effects, because some processes require that the camera be fixed, as the film is run through the camera several times and the image of one exposure must be positioned in exact relation to the other parts of the picture previously exposed. When cut into a picture that has been photographed by a roving camera, the effect shot, by comparison, may seem static and lifeless regardless of how well conceived and executed.

Some double exposure and matte shots have been made with the camera moving mechanism and the camera film-moving mechanism geared together. By beginning each take with the film and camera positioned on a start mark, the camera position will be the same for each picture frame, as the film passes through the camera for any number of operations. The use of this system is limited because the rate of movement must be predetermined and the action must follow the camera, which is an awkward, and sometimes an impossible, procedure.

A system for special effect shots has been devised and applied at present to panning and tilting the camera, which permits the cameraman to pan and tilt the camera in a normal manner and follow the action as desired. A record is made of the movement and, for subsequent exposures on the same film, the record controls the camera

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movement, matching the original relation between the camera position and picture frame during these subsequent exposures.

In this system the camera is moved by the output shaft of a differential gear system. Two synchronous motors are connected to this gear system in such a way that the output shaft rotates at a speed which is the difference in the speed of the two motors; in other words, if the two motors were connected to the same power source, the difference in speed would be zero and consequently the speed of the output shaft, which moves the camera, is zero and the camera is stationary. However, if one of the motors is connected to a power supply of a different frequency, the camera is moved at a rate that is in proportion to the difference of the frequency of the two sources.

In operation, one of the synchronous motors is connected to the electric power system and runs in synchronism with the power line frequency; the other, whose change in speed causes the camera to move, is fed by an amplifier and runs in synchronism with a control signal which is fed to this amplifier. This control signal is produced by an induction frequency changer. The three-phase primary of this frequency changer is also connected to the electric power system. With this type of frequency changer, the output frequency is the same as the input when the rotor is at standstill and increases in proportion to the speed of rotation if the rotor is revolved in one direction and decreases proportionately if reversed. Therefore, the camera movement follows the rotation of the frequency changer shaft.

This control signal is also fed to a recording system and recorded when the first take is made.

A "start mark" is placed at the beginning of the record and the beginning of the picture film. The recording machine and the camera are driven by a common-drive source so that they accelerate and run together and the length of the picture film and the record are in proportion through the running.

For subsequent running of the film through the camera, the camera and record-reproducing machine are lined up with their respective start marks as they were at the beginning of the first running and are driven by a common-drive system. The signal, which is fed to the amplifier driving the variable-speed synchronous motor, is reproduced from the record. Being identical in respect to frequency to the original signal from the frequency changer that produced the camera movement during the first run, the camera moves as it did during the first run. Thus, as each picture frame is moved into the photo-

graphic aperture, the camera is in the same position and angle as it was when that picture frame passed through the camera the first time. The camera is held in a fixed position for a short time at the beginning of the shooting. On subsequent running of the film this time interval is used to check and correct the camera position.

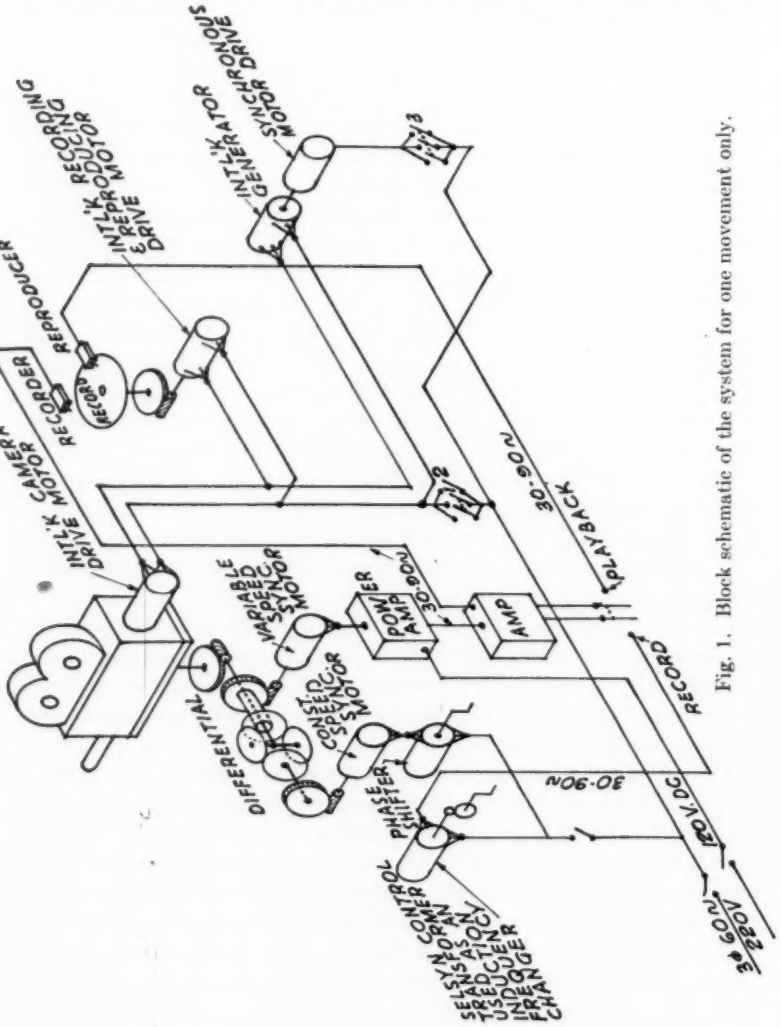

Fig. 1. Block schematic of the system for one movement only.

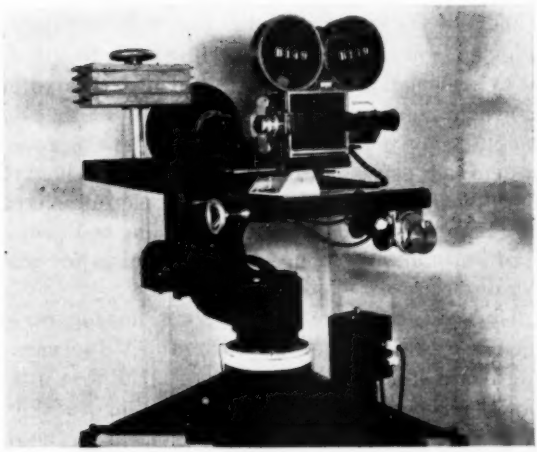

Fig. 2. Motion repeating machine for Technicolor camera, with Bell & Howell camera adaption.

Fig. 3. Recording and reproducing equipment and controls, with all electronic equipment mounted in portable cabinet.

The phase angle of the signal from the disc may vary a few degrees from the original signal; so after everything is up to speed this error is corrected by means of a phase shifter which is inserted in the constant-speed synchronous-motor line.

The common-drive system that is mentioned is the same electrical interlock system that is used in sound picture work to hold the picture and sound systems in synchronism for sound picture making and reproduction. It is also used to hold the camera and projection machine shutters and film movements in synchronism for making projected background process shots.

Figure 1 is a block schematic of the system showing, for simplicity, one movement only for panning the camera. A duplicate system is provided to elevate and depress the camera. Both records are made simultaneously on one disc. A system similar to the standard phonograph disc recording and reproducing system was used to record and reproduce the control signal.

The power amplifier which supplies the power to the variable-speed synchronous motor is in this application a thyratron inverter. This system is ideal for this job because variations in input voltage have no effect on the output voltage, provided the input voltage stays above the minimum necessary to fire the thyratrons. Also, the simple circuit used produces the necessary change of output voltage with frequency to operate a synchronous motor, at full torque, at all frequencies. Ample power is produced using the 120 d-c studio lighting power as a "B" supply.

Errors due to the shifting of synchronous-motor rotor poles, in respect to the applied frequency as it takes a load, are reduced by a factor of 800 to 1 in the gear train. A large portion of this displacement occurs when the motor accelerates or decelerates the camera, and as the motor has the same mass to move at the same point of its movement no visible error in duplication of movement due to this has been observed at any time. The present maximum rate of pan and tilt speeds is about 25 degrees per second, which is faster than any requirement encountered at present.

Mr. Richard Duval of the Development Engineering Department of Metro-Goldwyn-Mayer Studios has worked out lens position charts for the changing of focal settings between various shots.

Using a painting as the second subject photographed, a change of ten to one in focal distance has been made with no relative movement between the images photographed at these two settings.

Increased Noise Reduction By Delay Networks

By J. R. WHITNEY and J. W. THATCHER

Sound Services, Inc., Hollywood, Calif.

Summary—**This paper describes a new method of obtaining increased signal-to-noise ratio in optical sound film recording. This is done by increasing the noise reduction and is made possible by the use of delay networks which delay the application of sound currents to the modulator until after the noise-reduction-bias current has been partially canceled. Noise-reduction settings as high as 30 db have been tried with good success and settings of 15 db have been used in regular production.**

Recent developments in original sound recording such as 200-mil push-pull optical tracks and magnetic films have made original sound records far superior to the release tracks which are heard in the theater. Since it undoubtedly will be many years before anything except the standard non-push-pull optical sound tracks will be used in theaters, anything which will improve the quality of release tracks would be highly desirable.

One relatively easy way of improving the release track would be to increase the noise reduction now being used in all optical film recording.[1] However the use of noise reduction brings in some inherent disadvantages such as "clipping" and "thumping." Clipping is caused by the modulator overloading for a few syllables when sounds with sudden impacts are being recorded, because the cancellation of the noise-reduction-bias current takes an appreciable length of time. If this time is shortened too much in an effort to reduce clipping then the operation of the modulator by the noise-reduction currents approaches audible frequencies and thumping occurs. In practice the noise reduction unit is adjusted for a practical balance between clipping and thumping which together with the use of "margin" makes these sounds generally unnoticeable. Margin is the adjustment which determines the difference in decibels between the signal which just overloads the modulator and the signal which just cancels the bias current.

One method of reducing these undesirable noise-reduction effects

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so that increased noise reduction could be used would be to delay the application of the signal currents to the modulator until after the noise-reduction currents were partially canceled. Up to the present time this has not been practicable but with the newly developed Delay Network designed by the Bell Telephone Laboratories it has now become possible.

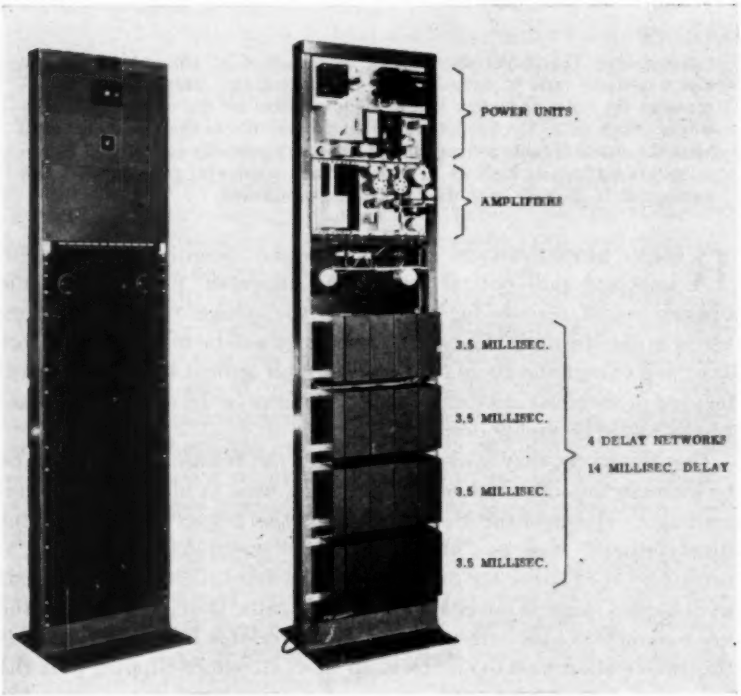

Fig. 1. Delay network rack, front and rear views.

For several years delay networks have been used in radio receiving systems, automatic recording oscillographs, transoceanic radio telephone service and radar.[2] The design of delay networks is based on the principle that electrical energy supplied to inductances and condensers can be stored for an appreciable length of time in the electromagnetic and electrostatic fields of the coils and condensers. This storage creates a time delay between the receipt of a signal at

the input to the network and its delivery to the output. If the network is designed to have different amounts of delay at different frequencies it is called a delay equalizer; while if it is designed to have a constant delay for all frequencies it is usually referred to as a delay network. It is relatively easy to design a delay network to cover a limited band of frequencies but it is very difficult to design one which will cover the full audio-frequency band. The new networks are designed to cover the frequency range of 50 to 8000 cycles and have been made possible only by the great amount of experience gained by the Bell Telephone Laboratories in recent years in designing delay networks. Each network has a constant attenuation of about 13.5 db and a time delay of $3\frac{1}{2}$ milliseconds. Delay times in multiples of $3\frac{1}{2}$ milliseconds can be obtained by using the networks in series.

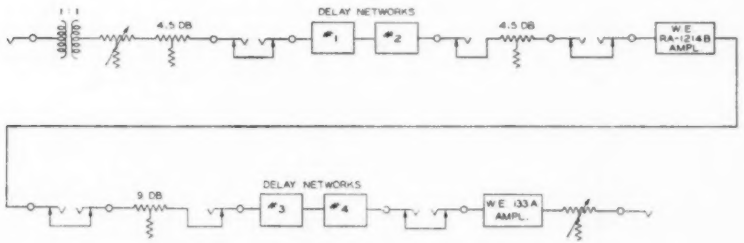

Fig. 2. Delay network rack, block diagram.

For reasons explained later it was decided that in production sound recording, four networks in series, having a time delay of 14 milliseconds, would be used. These networks, together with the necessary amplifiers, power units and attenuators, were assembled on a rack (Figs. 1 and 2). The delay network rack circuit was designed to have a zero insertion loss and enough output capacity to drive a light-valve modulator. On the recommendation of the Bell Telephone Laboratories the circuit was so designed that no network would have an input power exceeding zero dbm. Following good engineering practice, the networks are isolated by attenuators from possible variations in impedances. As shown in Fig. 3 the delay network rack is patched into the re-recording channel just ahead of the modulator and after the noise-reduction-amplifier input bridging point. In this way the speech currents are applied to the noise reduction amplifier 14 milliseconds before they arrive at the modulator. By

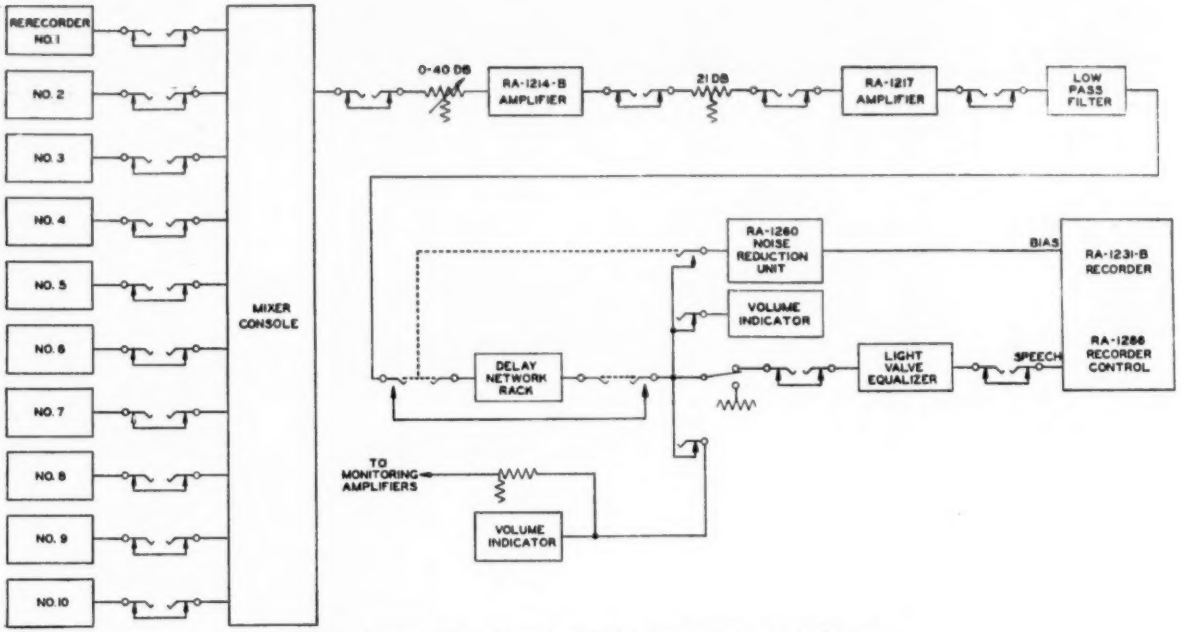

Fig. 3. Re-recording channel with delay networks, block diagram.

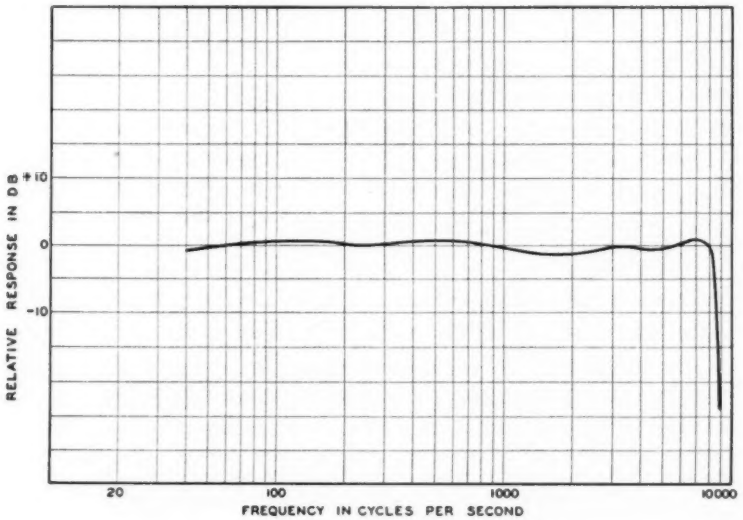

Fig. 4. Delay network rack, frequency characteristic.

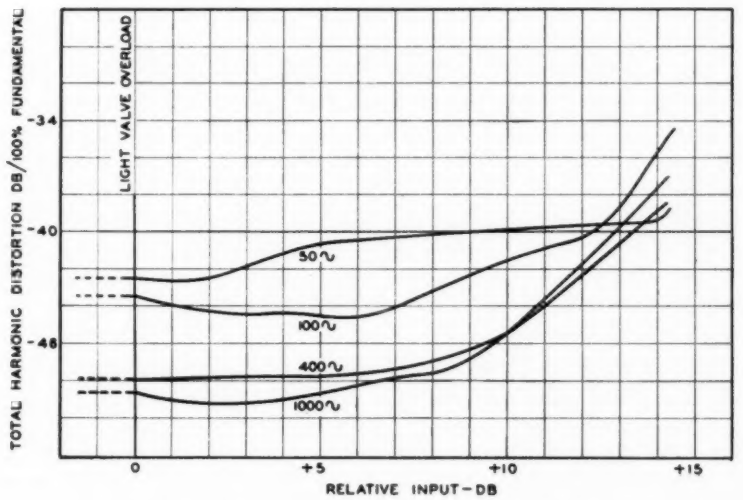

Fig. 5. Re-recording channel, harmonic distortion.

having the network rack have a zero insertion loss, it can be removed or inserted in the channel without the necessity of changing the channel operating adjustments.

The gain frequency characteristics of the network rack is within ±1.5 db over the range of 50 to 8000 cycles (Fig. 4).

Distortion measurements made on the re-recording channel, which was a regular Western Electric 435 D re-recording channel using an RA-1231 B recorder and RA-1251 B re-recorders, show that including the delay networks the distortion for any frequency above 50 cycles is less than 1% for inputs up to 9 db above the light-valve overload point. At light-valve overload the distortion at the same frequencies is less than ¾% (Fig. 5).

After considering the possible uses for delay networks in a sound recording channel, it was agreed that the most advantageous use would be to increase the signal-to-noise ratio in release prints. While the networks could be used to reduce undesirable noise-reduction effects such as clipping and thumping, it was believed that an increased release volume range was preferable. Consequently, our tests have been limited to that field.

A normal noise-reduction setting for single variable-density recordings is 10 db with the noise-reduction filtering adjusted for an attack time of from 16 to 22 milliseconds. Attack time has been defined as the time required for the bias current to undergo 90% of its total change when a signal having a magnitude somewhat less than the value required to cancel the bias fully is applied to the noise-reduction unit. Since the movement of the light-valve ribbons is proportional to the amount of current flowing through them, the average spacing of the light valve will be directly related to the bias current. The characteristics of the noise-reduction timing filter on attack signals are such that the rate of opening of the biased light valve is not constant but is greatest at the beginning and decreases to zero at the end. For a given noise-reduction timing, the rate of opening varies with the noise-reduction setting, being faster for increased noise reductions.

Since it was planned to use high values of noise reduction and since the rate of valve opening was to be retained at about the same value as was normally used, the timing filter was modified to have an attack time of about 24 milliseconds or about 25% longer than normal. With this filter and a noise-reduction setting of 15 db, the rate of valve opening is about the same as with a normal 19-millisecond filter and a

setting of 10 db. With the modified filter, the valve opens to 41% of its average spacing in 14 milliseconds (Fig. 6).

With a delay time of 14 milliseconds and with the modified filter, it was calculated that the valve could be completely closed and that less clipping of initial sound would occur than with normal operation at 10-db noise reduction. With this in mind, re-recording tests were made with music and dialogue with noise-reduction settings of from 0 to 30 db and with margin settings from 0 to 6 db. These tests showed that the use of high values of noise reduction was entirely feasible although as much as 30 db was undesirable since at that value the sound quality began to deteriorate somewhat. These tests also indicated that margin settings greater than zero were unnecessary

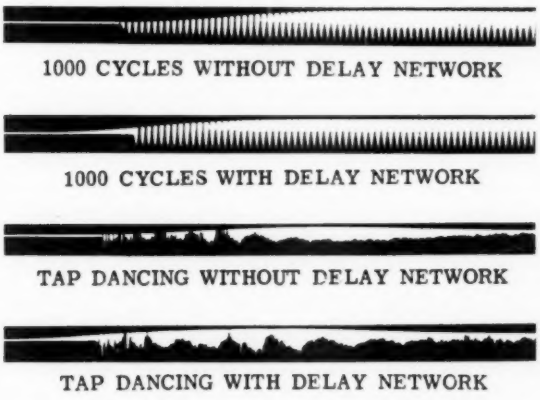
1000 CYCLES WITHOUT DELAY NETWORK
1000 CYCLES WITH DELAY NETWORK
TAP DANCING WITHOUT DELAY NETWORK
TAP DANCING WITH DELAY NETWORK

Fig. 6. Sound tracks with and without delay networks.

to prevent clipping, although the use of up to 6 db of margin caused no harm. However, the decrease in film noise made 96-cycle sprocket-hole modulation more apparent. For this reason it was decided to use a value of 15-db noise reduction for actual production re-recording.

Sound Services, Inc., have been using this value of noise reduction for over a year with various types of product with completely satisfactory results. In a number of cases the increased noise reduction has been very helpful in allowing a decrease in the normal recording level so that special effects could be obtained.

While most of our experience has been with density recording, we have also used the networks with success in variable-area recording. Here the problem is one of obtaining as narrow a bias line as possible

without getting excessive clipping action. In order to reduce the low-frequency thump action which would have been accentuated by the increased rate of change of the noise-reduction ribbon due to the smaller valve spacing, it was necessary to increase the attack time of the noise-reduction filter as was done for density recording. An attack timing of 32 milliseconds was used.[3] With no other change, we were able to bias down to a bias line on the film of 1 to 1½ mils with good results. Experience with this small bias line has shown that films that have been projected many times in theaters still exhibit very little film noise.

While a good deal of practical experience has been obtained in the use of 14 milliseconds of delay, no extensive investigations have been made regarding optimum time of delay, the best speed and type of noise-reduction attack timing, or the practical limits to the amount of noise reduction which can be used. Tests such as these should be made in the laboratory and the conclusions tried out under practical operating conditions.

CONCLUSIONS

Delay networks with a time delay of 14 milliseconds over the audio-frequency range of from 50 to 8000 cycles have been used in sound film recording to obtain additional noise reduction. Through the use of these networks noise reductions up to 30 db have been tried and 15 db has been used in production for a period of over a year. One of the limiting factors in using more noise reduction is sprocket-hole modulation which becomes more objectionable as noise reduction is increased. The use of the delay networks is advantageous in both variable area and variable density recording. They are especially desirable since the improvements gained through their use are obtained in the final release negative.

NOTE: The presentation of this paper was supplemented by a demonstration film which was designed to show the possible uses of high noise reduction.

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(1) R. R. Scoville and W. L. Bell, "Design and use of noise reduction bias system," *Jour. SMPE*, vol. 38, pp. 125–147; February, 1942.

(2) H. M. Thomsen, "New voice frequency electrical delay network," *Bell Labs Rec.*, pp. 15–18; September, 1940.

(3) Kurt Singer, "Versatile noise-reduction amplifier," *Jour. SMPE*, vol. 50, p. 562; June, 1948.

Miniature Condenser Microphone

By JOHN K. HILLIARD

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Summary—**This paper describes a miniature microphone that has been reduced in size so that an extremely uniform frequency response is obtained from all angles of pickup. Although it is very small its output level is high. Because it is so small, it can be used in many applications not possible with larger and heavier microphones. Uses of the microphone in motion picture sound recording indicate a different placement and pickup technique can be used. Having simple parts, its uniformity of production can be extremely high. A description of different models is given along with suggested methods of using the microphone.**

Dolbear described a condenser microphone in 1882 and such a device was reported as being shown at "La Lumière Electrique" in 1881.[1] Later Wente[2] produced a commercial unit which had extensive application in the first years of sound motion picture recording. It was then replaced by dynamic, ribbon and directional microphones. Later smaller condenser microphones were described by H. C. Harrison and P. B. Flanders[3] and also by F. L. Hopper.[4] The principal objections to the early condenser microphone designs resulted from such factors as: (1) diffraction effect due to its comparatively large size; (2) cavity resonance; and (3) electrical circuit complications.

In using a microphone the sound reaching it directly is, in most cases, only a very small part of the total. Most of the sound arrives from random directions, the amount being picked up directly depending upon the reverberation of the room and the distance from the source. When the microphone has a response which differs in the various directions, the output fails to be an exact reproduction of the source. Under these conditions, one form of distortion is introduced by the microphone. The directivity of pressure type microphones, such as condenser type, results from two factors: (1) the variation of the diffraction effect and the angle of pickup; and (2) the decrease in pressure caused by phase shift which occurs when the direction of the sound has a component which is parallel to the plane of the diaphragm.

Each of these effects is a function of the size of the microphone relative to the wavelength of sound.[5]

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DIFFRACTION

An extremely small size of the microphone is required in order to minimize the variations in directivity with angle. If this effect is to be held negligible ($\pm$ 1 db at 10,000 cycles) the diameter of the microphone must be approximately no greater than $\frac{1}{2}$ in. The diffraction effect is the more important of the two factors described above, where the wavelength becomes comparable to the diameter of the diaphragm. This is the effect which makes a difference between the "free field" and the "sound pressure" measurement calibration of a

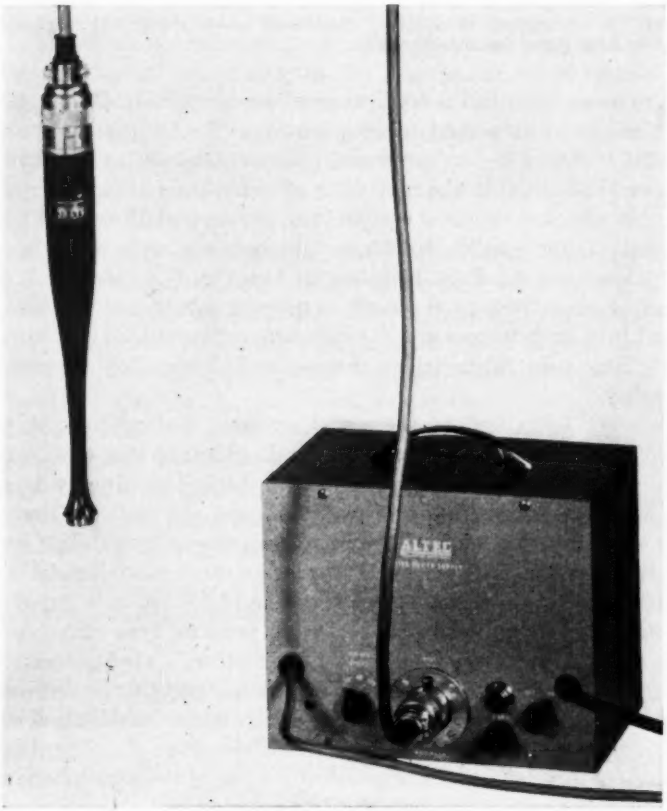

Fig. 1. M11 microphone system.

microphone. With these unescapable fundamental principles established, there appears to be only one way in which diffraction distortion can be reduced to a negligible degree, and that is maintaining an extremely small size. Calculated diffraction effects have been checked very closely with data obtained from "free field measurements."

The two most commonly used types of housings for pressure operated microphones are the cylinder and the sphere.

When a microphone is built to have the fundamental shape of a cylinder, the diffraction effect is such that when sound arrives perpendicular to the end of the cylinder which represents the diaphragm (upper part of Fig. 2), the response increases by a factor of approximately 8–10 db when the ratio of the diameter to the wavelength of sound is unity. At frequencies above this point, a series of variations by this same amount occurs at intervals. In the case of a sphere

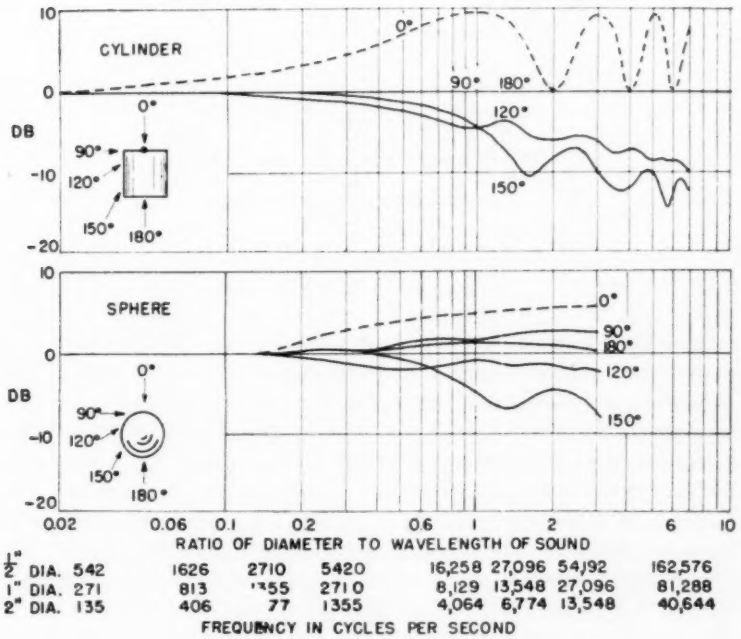

Fig. 2. Effect of diffraction.

(lower part of Fig. 2), the output perpendicular to the axis is uniform at a value equal to that for a ratio of the diameter to the wavelength of unity. The cylinder shows a larger variation than the sphere which has a minimum variation of 12 db when the ratio of diameter of wavelength to sound is greater than 1.5. These data indicate that while it might be technically possible to equalize the on-axis response to be uniform, a variation of not less than 12 db will be encountered for the various angles of pickup for this ratio.[6,7]

DESIGN

Having established the fact that miniature size is a necessary requirement to reduce this form of distortion, effort has been directed to design and produce a commercial microphone meeting the requirements of size along with sufficient output to maintain the necessary signal-to-noise ratio. Figure 3 shows a cross-section diagram of the

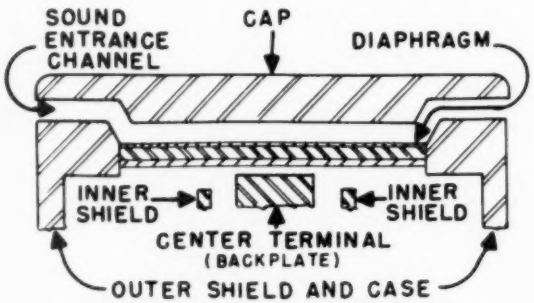

Fig. 3. Cross section of 21B microphone.

essential portions of this miniature microphone. They consist of a diaphragm and an electrode or backplate in close proximity. The backplate and diaphragm being closely spaced, constitute an electrical capacitance which varies with microscopic deflections of the diaphragm caused by pressure variations in the sound wave. The backplate or center terminal is polarized with respect to the diaphragm through an extremely high resistance so that a fixed charge accumulates on the center terminal. As the sound pressure actuates the diaphragm, the capacity of the microphone varies and a corresponding change in voltage between the center terminals and diaphragm exists. The resulting signal is applied to the grid of the vacuum tube which follows. The surface of the diaphragm facing the center terminal is

formed of insulating material, eliminating the problem of electrical breakdown between these parts.

The microphone base encloses a 6AU6 Miniature Vacuum Tube whose function is to translate the change in voltage generated by the microphone across an extremely high impedance to a nearly equal voltage across an impedance of 1200 ohms so that the signal can be faithfully transmitted over lengths of cables to subsequent apparatus. The circuit of the impedance transferring tube in the base is shown in Fig. 4. The microphone backplate receives its polarization through the elevation of cathode voltage above ground potential. It is a property of the cathode follower circuit that its input impedance is extremely high whereas its output impedance is relatively low.[8] Also, the effect of any capacity connected between cathode and grid is

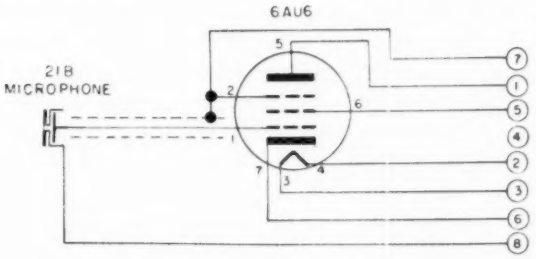

Fig. 4. 150A microphone base.

greatly reduced by the cathode follower action. Connections of the inner shield in the microphone permit it to be separated by a short distance from the vacuum tube. The extension between vacuum tube and microphone is intended to achieve the fullest advantage of the miniature size of the microphone without providing any additional obstacle size and its associated distortion. The microphone base contains only the cathode follower vacuum tube. All other components associated with it are located at the far end of the interconnecting cable. This is done to maintain the smallest possible base size.

The dimensions of the microphone are .6 in. in diameter and .4 in. thick. It weighs approximately 6 grams. A small circumferential sound entrance channel, 20 mils thick, is located on the side of the microphone. This aids in maintaining an omnidirectional characteristic and provides protection against mechanical damage to the diaphragm. The microphone is mounted on a base which is $8\frac{3}{16}$ in.

long and has a diameter of 1⅛ in. at the bottom which has a Cannon P-8 Plug. The top of the base is 1 3/16 in. in diameter. Since the top of the base is smaller in diameter than the microphone, it does not contribute any added obstacle interference.

The microphone and its base are connected to the power supply by means of a cable (up to 400 ft in length) whose construction is shown in Fig. 5. Signal transmission through this cable is equivalent to the use of coaxial cable. The three inner conductors which carry the signal have high capacity between them in the circuit. The outer conductors carry the other tube functions all of which are at ground potential for the signal. By this construction, the outer conductors serve to shield the inner signal conductor.

POWER SUPPLY

The power supply cabinet houses the components associated with the vacuum tube in the base as well as the output matching transformer, and the plate and filament power. The circuit of the power supply is shown in Fig. 6. Rectifiers are the selenium dry disk type and supply the necessary plate and screen voltages along with the heater current for the 6AU6 Cathode Follower Tube. While the cathode follower has a low output impedance, it must work into a load of relatively high impedances in order that it function properly. In this case, a load of 70,000 ohms is used. The matching transformer is then used to transform this impedance down to conventional values used in pre-amplifiers.

DESIGN CHARACTERISTICS

In the past a reduction in size of the microphone has lowered the sensitivity to such an extent that an adequate signal-to-noise ratio could not be maintained. In this microphone the sensitivity is, in spite of its size, sufficient to give −48 db below 1 milliwatt for a sound field of 10 dynes/sq cm at the output of the transformer. The open circuit voltage of the microphone is −50 db below a reference of 1 volt/dyne/sq cm. The electrical capacitance of the microphone is approximately 6 micromicrofarads. The diaphragm is 0.5 in. in diameter and is clamped on the edge. Since it is of laminated construction and part is composed of insulating material, its resonance is not determined by tension.

The frequency response of the microphone, including all apparatus up to the output of the matching transformer, is within 1 db from 40

cycles up to 12,000 cycles. Because of the simplicity of the mechanical and acoustical elements in the microphone, a very high degree of uniformity can be maintained between production units. This uniformity can be observed by placing two microphones immediately adjacent to each other. By connecting their outputs so that they are out of phase, a sound source will be canceled by a factor of approxi-

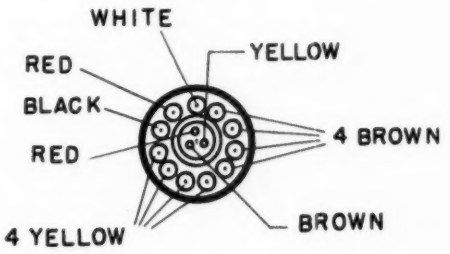

Fig. 5. Cross section of microphone cable.

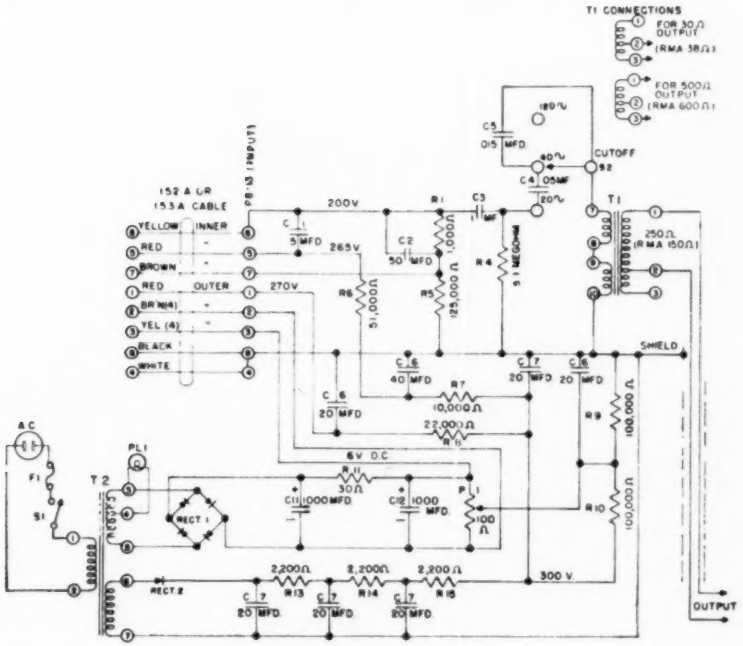

Fig. 6. P-518 power supply.

mately 30 db on a VU meter reading basis. This degree of cancellation can be achieved by virtue of the fact that since the diameter of the microphone is .6 in. the half-wavelength frequency is approximately 13,000 cycles/sec.

In this design the response of the condenser microphone extends to very low frequencies (approximately 3 db down at 10 cycles). In some cases, it is desirable to eliminate rumblings at low frequencies caused by the extraneous noise of traffic and ventilators. A switch is provided to reduce the low frequency response at a rate of 6 db per octave being down approximately 6 db at 20, 40, and 120 cycles.

USES

The small physical size of the microphone permits it to approach more closely the pattern of an ideal omnidirectional microphone at the very high frequencies. This characteristic is a material advantage where orchestra and solo channels are recorded separately and then later combined for proper balance. Directional or semi-directional microphones[9] provide less suppression at high frequencies than at low frequencies, and when the tracks are combined in recording, the high frequency content of the orchestra in the solo channel is distorted in characteristics and phase, and undesirable effects are obtained in the release product.

Use of the miniature condenser microphone for the scoring of music in motion pictures has indicated that the usual microphone placement practice can be modified. Instead of using several microphones placed near individual instruments, one miniature condenser microphone can be placed so as to obtain a good balance on the over-all orchestra. Setups have been made with all of the commonly used groups of instruments such as for main title, background scoring, small dance band routines, and full symphonic numbers. A considerable saving in time has resulted from this technique as the time required to place and balance multiple microphone setups is eliminated. The practice to date indicates that the single condenser microphone can be placed in a position directly above the conductor's head (Fig. 7). The conductor places the instruments so that the required balance is obtained. The sound mixer then has the primary function of maintaining the proper modulation on the film whereas the conductor is responsible for balance. Where more than one channel is used such as in the cases of prescoring with voice, a chestplate type of microphone has been used so as to provide the necessary isola-

tion between the orchestra and solo channels (Fig. 8). This is accomplished by placing the soloist very close to the director. Approximately 10 db of suppression on the orchestra is obtained by the use of this chestplate since the soloist is permitted to operate extremely close to the microphone without the undesirable effects usually associated with close operation (Fig. 9). Some of the advantages resulting from this technique are:

(1) The soloist is in a position which closely parallels that of concert work, and in so being hears the full volume of the orchestra and has the maximum benefit of the conductor's direction.

(2) The orchestra pickup in the solo channel has a frequency response which is equal to the orchestra channel except for volume.

(3) Re-recording for release is simplified since the phase of the orchestra in the solo channel is similar to that in the orchestra channel. This permits overlapping without undesirable effects. One of these undesirable effects results from the fact that when directional microphones are used to provide the necessary suppression between orchestra and solo channels, the suppressed frequency response is

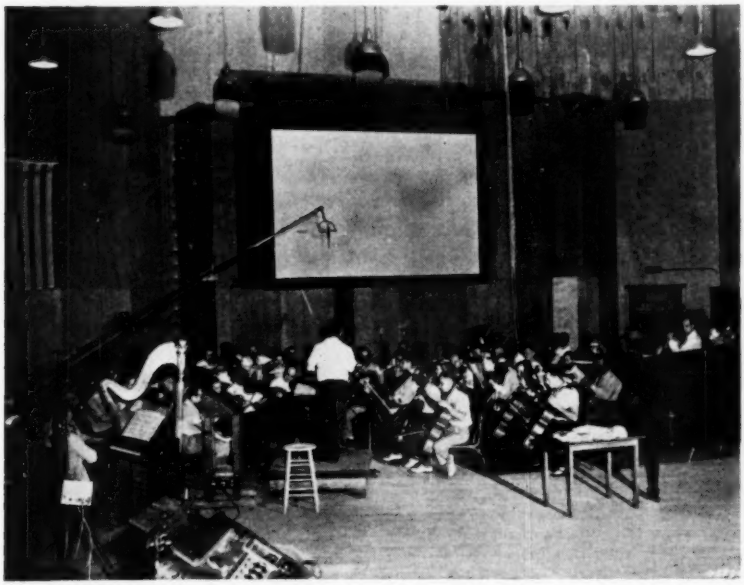

Fig. 7. Typical microphone position for recording orchestra.

such that the high frequency content is suppressed considerably less than the low frequency content. In most cases this suppression amounts up to 10 to 15 db between 1000 and 8000 cycles.

When ribbon microphones or various combinations of this principle are used, the phase shift between the particle velocity and the sound pressure causes a change in low frequency characteristics which is a function of distance from the source. At a distance of 2 ft the increase in response is approximately 2 db but at a 6-in. distance the increase is 10 db. In the case of the miniature condenser microphone, this phase shift does not occur and consequently the microphone can be used at distances extremely close to the source without producing this false bass.

In sound motion picture recording the microphone is one of the very important links in production since it involves the final quality and the various compromises that must be made by set designers, cameramen, and sound departments in order that the microphone be placed in its optimum position with a minimum of delays to the production company. Elaborate booms have been provided for both "panning" and "tilting" the microphone. Panning is required in order that fixed distances be maintained between the actor and microphone for best and uniform quality. Tilting has been required because the microphone has a varying high frequency response, depending upon the angle between the face of the diaphragm and the actor. The size of the boom has been dictated by the weight of the microphone and the mechanism required for panning and tilting. An extremely lightweight microphone reduces the demand for heavy construction and counterweighting. The elimination of tilt further reduces the complexity of controls on the boom. Use of condenser microphones in general, over a period of years, has indicated that they are less susceptible to wind disturbances than other types of microphones which have been used in motion picture production. A very small wind screen consisting of four layers of voile is provided as an accessory to the microphone. The attenuation of this material does not exceed 1 db at 10,000 cycles and provides up to 15 db suppression of wind noise.

CONCLUSIONS

This paper has stressed the improvements in sound quality and directional effects caused by the small size of the microphone. All of the features discussed contribute to produce a readily discernible

Fig. 8. 155A chestplate microphone.

Fig. 9. Relative position of soloist to conductor and orchestra.

improvement and a distinct step forward in the quality which can be obtained in sound reproduction. Experimental use over several months has indicated that under conditions varying from Carnegie Hall broadcasts to stage, motion picture, and television, obvious improvements in sound quality have been attained.

NOTE: In addition to the paper, a demonstration at the Academy Award Theatre of various types of recording, which included main title, background, combination of orchestra and solo channels, was presented. It was derived from material made by Mr. Alfred Newman of the Music Department at 20th Century-Fox Studios and the co-operation of their Sound Department.

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Supplementary Magnetic Facilities For Photographic Sound Systems

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Summary—**To facilitate the introduction of magnetic recording on 35-mm film, modifications have been engineered for adapting photographic recording and reproducing systems so that they may be used alternatively for either photographic or magnetic recording. Existing transmission systems employed in photographic recording have been modified to include a bias-erase oscillator. Magnetic heads have been added to the film recorders in such a manner still to permit the use of the recorder for photographic recording. Re-recorders have been modified for magnetic only or for alternative magnetic or photographic reproduction. The existing photocell amplifier has been modified for the dual reproducing facilities.**

To facilitate the introduction of synchronized magnetic recording into sound motion picture studios, it is highly desirable during the transition stage from photographic to magnetic to utilize as much as possible of the existing sound recording and reproducing equipment with a minimum of modifications. This serves the dual purpose of lessening the economic burden of the change-over and at the same time expanding the over-all recording facilities of the studios. As magnetic recording takes a firmer hold in sound motion picture production, emphasis will undoubtedly shift toward using facilities intended primarily for magnetic recording; but in the interim period the use of the dual-purpose equipment will meet with much favor.

At the time of writing this paper, the use of magnetic recording in the motion picture studios has not progressed much beyond the stage of using the medium for original recording. One of the dual equipped recorders described below may be employed for this purpose. The accepted takes are usually transferred from magnetic to photographic tracks of either the density or the area type, and the usual photographic re-recording and cutting techniques are then followed from this point. In transferring to photographic film, the "magnetic only" re-recording machine described below is preferred, and the photographic recording may, as in many small studios, be done on the dual-

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purpose recording machine. With the equipment described below either 200-mil push-pull area or density, or 100-mil single density or area may be recorded. Provision is also made for transferring the magnetic to either a direct-positive area or density track.

The design details of the components and the operating characteristics of the magnetic systems described below will not be reviewed in this paper as they have been thoroughly discussed in an earlier paper.[2] It will be noted that although the high-frequency erase facilities previously described are provided in the systems described below, the current practice in the Hollywood studios is to use a bulk 60-cycle eraser rather than the erase head mounted in the recorder. The use of low-frequency pre- and post-equalization has become well established in the industry, but the use of high-frequency pre- and post-equalization remains optional at this time.

MAGNETIC RECORDING FACILITIES

The recording and reproduction from magnetic film are being accomplished by two general methods with relation to the film path encountered in existing Western Electric film recorders of the RA-1231 type. The first consists of placing the magnetic head so that it bears on the overhanging portion of the film at the scanning drum in a manner analogous to that used in photographic reproduction. This is frequently referred to as the preferred position, since flutter and amplitude modulation are minimum at this point. The second method is that of placing the head in an open film path, such as between the recording drum and one of the compliant filter rollers, and this method is frequently referred to as loop scanning. The performance under this condition is dependent upon several design factors, but in general is not as good as the drum position with respect to high-frequency flutter rates. Typical flutter values for the drum position in either recording or reproduction are .06% to .08% total flutter, most of which is found in the higher flutter rates with low-rate components very small, the over-all performance being comparable to photographic recording. Flutter values for the loop position are substantially the same at all lower flutter rates, but are somewhat greater at the higher rates, particularly at the 96-cycle sprocket hole rate. The amount is somewhat dependent upon the relationship between sprocket pitch and that of the film, but for normal operating conditions is well below the accepted threshold limit for perceptibility.[2] It has been shown[3] that the fundamental

relationship between flutter rate and its minimum perceptibility will permit much larger values at high rates. For example, flutter at 96-cycle rate may be nearly 10 times that at rates between 5 and 10 cycles for equivalent perceptibility.

The addition of magnetic recording and monitoring facilities to the RA-1231 film recorder is shown by Fig. 1. The magnetic head at the drum position is shown as the light-colored circular object located in front of the recording drum and bearing upon the overhanging edge of the film which has the magnetic coating on the inside surface. An identical magnetic head used for monitoring may be seen at the right just above the film and located in the film loop between the recording drum and the lower right-hand filter roller. Both heads are adjustable for azimuth and track position and the recording head mounting is pivoted so that it is pressed against the film with a controlled pressure at all times to compensate automatically for factors such as film curl. This arrangement maintains proper contact at all times between the surfaces of the head and the film coating, and its motion is well damped to maintain stability and damp out small transient motions such as those produced by a splice passing the head. The recording-head mounting is also provided with a device for retracting the head and holding it away from the film to prevent contact during photographic recording, particularly in the case where the modulator is moved toward the front of the machine to record on the outside edge of the film for producing direct-positive sound tracks without the necessity of reversing the direction of motion of the film in the recorder.

Good contact is maintained between the film and the monitor head by virtue of the uniform and constant tension in the film path between the two sprockets.

A magnetic erase head is also available for application to this recorder, although it is not shown in Fig. 1. When required, this head is mounted in a manner similar to the monitor head and is located to the right of the film in the path between the left-hand sprocket and the left-hand filter roller so that the film may be erased ahead of the recording point.

For magnetic recording, the film magazine is replaced by a reel adapter mounted in the same manner as a magazine. It permits the use of either the 10-in. sheet-metal reel having a 2-in. hub, or the preferred reel having an 11-in. diameter with a 4-in. hub. All magnetic conversion parts are available in kit form and may be applied

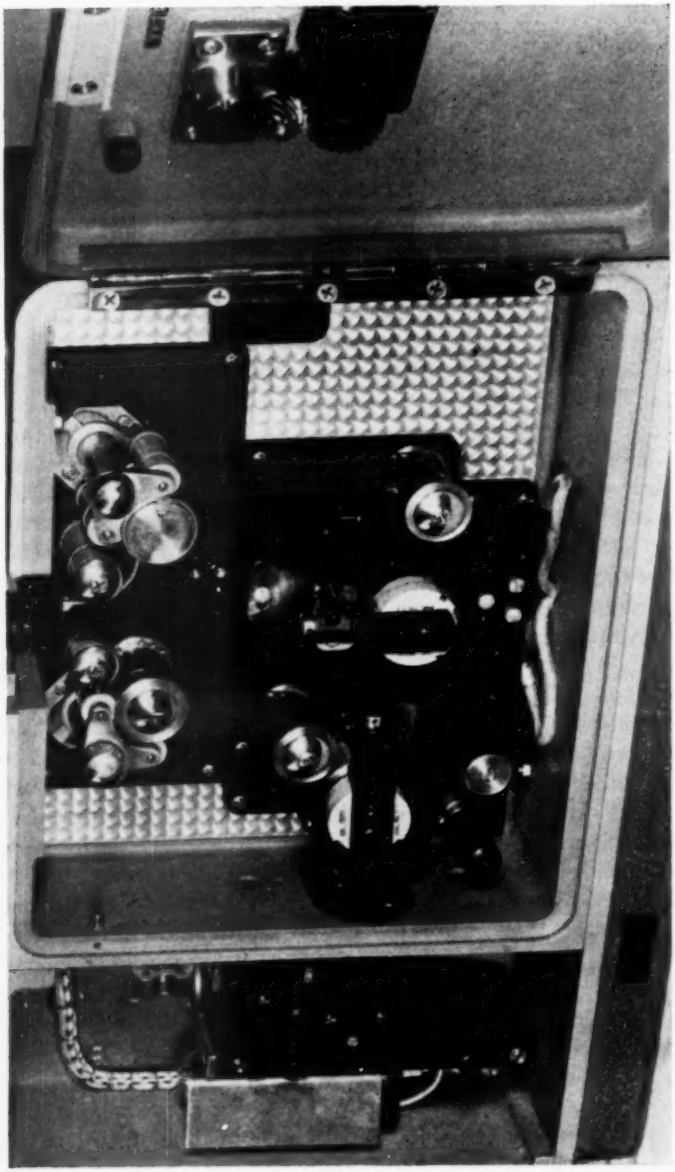

Fig. 1. Front view of RA-1231 Recorder equipped for magnetic recording and monitoring in conjunction with negative or direct-positive, variable-area photographic recording.

to any of the Western Electric RA-1231 type of film recorders without impairing in any way their usefulness as photographic recorders. Thus it is possible to have alternative magnetic variable-density recording or alternative magnetic and variable-area recording on any of these film recorders.

MAGNETIC REPRODUCING FACILITIES

Magnetic reproduction may be roughly divided into three classifications: immediate playback following recording (which for convenience should be done on the same machine making the recording), magnetic re-recording operations requiring adaptation of existing re-recording machines and magnetic reproduction in theater-type reproducers for use in the studio review room.

The immediate playback is available by using the monitor facility of the RA-1231 Recorders as described above, or in certain cases where high-quality performance is required, the recording head may be electrically reconnected and used for reproduction.

For the re-recording of magnetic tracks, two modifications have been made available for the RA-1251 type of re-recording machines recently described,[4] in which both the drum and loop scanning positions may be utilized. The first of these uses the preferred drum position as shown by Fig. 2, which is a close-up of the center section of the machine. All of the facilities for photographic reproduction are removed and a magnetic head is placed within the film drum contacting the over-hanging position of the film in the same manner as in the recorder. The magnetic head is pivoted and mounted in the same manner to insure adequate contact between the head and film under all conditions of operation. Similar adjustments for head orientation, azimuth, track position and pressure are provided. The only changes required in the film path or machine facilities are those directly related circuit functions pertaining to the equipment removed and the transmission facilities which are described later. The second modification consisting of placing the magnetic head in the loop position is shown in Fig. 3. This permits the retention of the standard photographic reproducing facilities so that the machine is available for either magnetic or photographic operation. The magnetic head is contained within the small rectangular unit mounted between the impedance drum and lower filter roller as shown by Fig. 3. This unit also contains a fixed idler roller so that for photographic

operation, the film is threaded over this roller instead of through the slot as shown in the figure. The change in film-path angle between these two methods of threading also serves to compensate for the added friction of the film over the magnetic head so that the two filter rollers operate in substantially the same positions with both types of film. This modification requires little change in the basic machine, except for the addition of the head assembly as shown

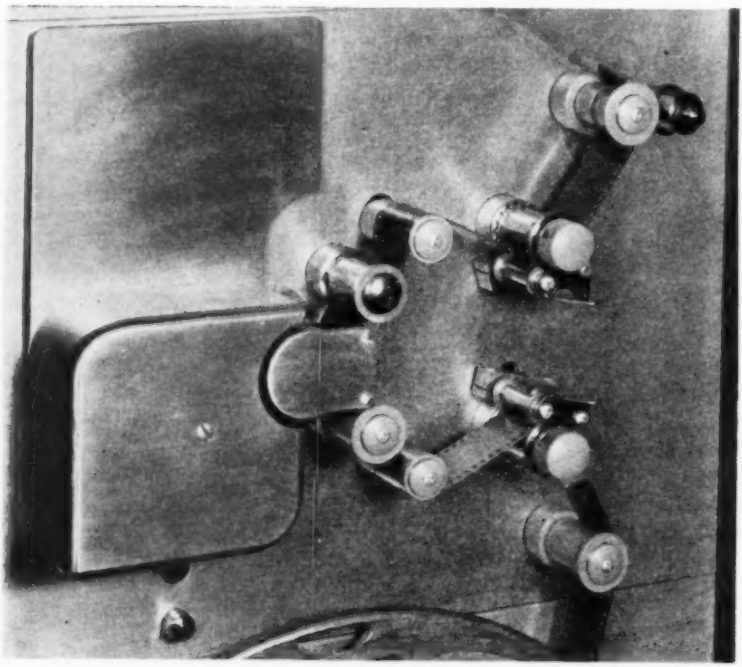

Fig. 2. Close-up of RA-1251-B Re-recorder equipped for magnetic reproducing (or recording) at the drum position for optimum flutter performance.

which replaces a fixed roller. The magnetic head is terminated in a plug on the rear of the removable mechanism section and provision has been made so that the photocell amplifier may be utilized as a magnetic head amplifier to provide an over-all flat frequency response, as described later.

Both of these modifications are available in kit form for application

to existing equipment, and in the event that either of these magnetic modifications is desired for recording purposes, an erase head unit has been designed to be mounted in much the same manner as described for the recorder. Figure 3 shows this erase head assembly mounted in the film loop between the upper sprocket and the first filter roller in combination with the photographic and magnetic

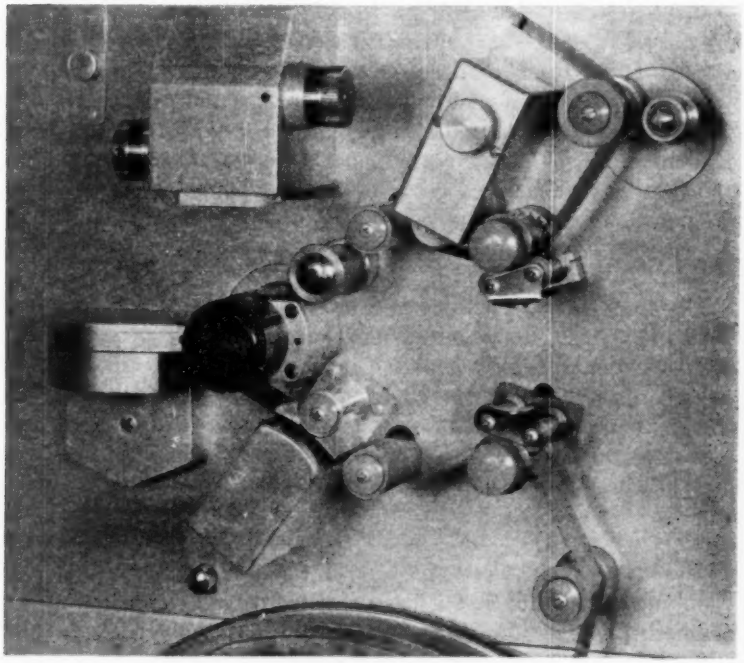

Fig. 3. Close-up of RA-1251-B Re-recorder equipped for both photographic and magnetic reproduction and erasure, with the film shown threaded for magnetic operation passing over the magnetic head under the cover located below and to the right of the impedance drum.

modification. A knob on this unit retracts the head from contact with the film during photographic operation to avoid film damage, but does not in any way affect the other performance characteristics of the film pulling mechanism. A similar assembly is available for the other modification employing drum scanning, but it is of course located on the other side of the film, since the coating is on the other

side in this type of operation. In this case the magnetic head is fixed, without the retractable feature, since photographic film is not encountered.

REVIEW ROOM FACILITIES

A new theater reproducer, which is primarily intended for wide-track photographic reproduction in studio review rooms, has been described recently.[5] Figure 2 of that previous paper shows the reproducer equipped with a magnetic head located in the loop position directly below the scanning drum. Since this machine is designed for both photographic and magnetic operation, the magnetic head is also retractable so that it does not contact photographic film, to avoid scratching. The flutter performance is essentially the same for photographic and magnetic except for the higher values at higher rates as discussed above.

TRANSMISSION FACILITIES

The transmission facilities of both the portable (300 type)[6] and deluxe (400 type)[7] recording systems have been adapted for use with the magnetic recording machines described above. As in the case of the recorders the modifications have been made in such a way that the photographic facilities are retained and change-over between the two types of operation is readily made. The modification parts have also been provided in kit form to permit conversion in the field.

"300 TYPE" PORTABLE SYSTEM

Although compactness was one of the primary features of the "300" system design, it has been possible to add the magnetic and magnetic-photographic change-over facilities without adding to the number of component units or increasing the over-all size of any of the units. All changes have been confined to the recorder, including the photocell monitor assembly mounted within it, and the main transmission unit. The adaptation has been applied to both the variable-density and the variable-area versions of these units.

The modifications of the main transmission unit for alternative variable-density photographic or magnetic recording are described below.

High-Frequency Bias. A high-frequency bias signal superimposed on the speech signal is normally used in high-quality magnetic recording systems to minimize distortion caused by the nonlinear

characteristics of the magnetic medium.[1] In this system it has been possible, by relatively minor circuit modifications, to utilize the 30-kc carrier frequency oscillator associated with the noise-reduction circuit as a source of high-frequency bias signal.

In the modification, the signal frequency is changed from 30 to 60 kc to obtain a greater spread between speech and carrier for minimizing intermodulation components. This change does not affect the performance when operating as a noise-reduction circuit.

To prevent modulation of the carrier by the speech signal (as is done in normal noise-reduction operation) the oscillator is disconnected from the rectified audio signal under magnetic operation.

In the noise-reduction output circuit, the output transformer is replaced with one of equivalent performance except for an added 600-ohm output winding to operate into the recording magnetic head. Also a means of metering the high-frequency signal using the D-C Noise Reduction Bias Meter is provided. The oscillator circuit is capable of supplying over 30 milliamperes to the output circuit, which is more than ample for optimum recording conditions.

Frequency-Response Characteristic. The low-pass filter normally used in 16-mm recording has been modified to provide a relatively sharp cutoff at 9,000 cycles per sec for magnetic recording. This prevents the high-frequency bias from feeding back into the amplifier output circuit where it would affect the volume indicator or meter reading and possibly introduce intermodulation components.

Power Supply to Monitor Amplifier. The heater supply to the associated monitor amplifier in the recorder has been connected to the 12-v d-c line instead of the 6.3-v a-c line. This retains the monitor system hum level at a satisfactorily low level, whereas it would otherwise be emphasized under magnetic operation due to the 6 db per octave slope of the reproducing system frequency-response characteristic. A ballast lamp is added for current regulation under the conditions of variable alternating-current supply voltage and variable current drain to the recorder lamp.

The variable-area version of the main transmission unit has not previously been described in the JOURNAL. It differs from the variable-density unit principally in that peak-chopping has been provided, the light-valve equalizer has been modified to provide characteristics complementary to those of the variable-area light valves and the noise-reduction filter has been adjusted for optimum variable-area attack and release times.

The magnetic facilities are essentially the same for the variable-density and variable-area versions of the main transmission unit, the peak-chopper circuit in the latter version being disabled when recording magnetically in order to utilize fully the gradual overload characteristic of the magnetic medium.

By furnishing the modification parts in the form of wired sub-assemblies, the change-over can be made economically in the field with a minimum disturbance to the original components and wiring.

Monitor Amplifier in Recorder. Alternative magnetic and photographic film monitoring is accomplished by installing in the rear compartment of the recorder a new monitor amplifier. This amplifier has a photocell input for photographic operation from the modulated light beam and a low-impedance transformer input for operation from the magnetic monitoring head. An internal transfer switch connects the desired input circuit and also selects between two feed-back circuits around the first two stages; one provides a flat characteristic for photographic and the other a 6 db per octave slope for magnetic monitoring.

With magnetic operation a signal-to-noise ratio better than 50 db can be obtained from an over-all flat reproducing system. This value is considered adequate for portable production applications and therefore pre- and post-equalization has not been added.

"400 TYPE" DELUXE RECORDING SYSTEM

In the deluxe, "400," photographic recording system, such as used in major studios for production, scoring and re-recording, the various electronic components are separately packaged units adaptable for mounting in standard equipment cabinets or custom-built consoles. These transmission assemblies normally operate in conjunction with the deluxe variable-density or variable-area recorder and the automatic recorder control cabinet.

Modification of these systems for alternative magnetic and photographic operation has been accomplished by providing modifications of two of the existing system components and adding two new components as described below.

Photocell Monitor Amplifier. This amplifier, mounted in the recorder control unit, normally operates from a photocell mesh circuit and provides a flat over-all frequency response for monitoring at an output level of approximately 0 dbm. By adding an input transformer, a magnetic reproducing characteristic of 6 db per octave

slope and a switch for transferring between the two circuit conditions, the amplifier can be made to function for both types of recording. The output attenuator can be adjusted as required to provide direct and film-monitor balance in both cases. This modified amplifier is also used in the modified re-recorders described above to provide a flat over-all response characteristic when re-recording or reproducing from magnetic film.

Recorder Control. A feature of the standard photographic recorder control unit is the provision for automatic switching, in proper time sequence, of the recorder speech input, noise-reduction bias, recorder lamp, motor and other miscellaneous circuits at the beginning and end of each take from a single start-stop push button. This is accomplished by a positively driven multiple-cam assembly operating on a series of individually adjustable micro-switches. Protective interlocking features are also included.

In the magnetic modification both the manual and automatic operating features are retained for both types of operation. By operating two transfer switches within the unit the following circuit changes are made:

(a) Speech Off-On switch is transferred from the light valve to the magnetic head circuit.

(b) Power to the light meter and noise reduction unit is transferred to the bias-erase oscillator which is one of the added units described below.

(c) The meter used for measuring exposure is transferred to measure bias and erase current.

In addition, several items are added on completely wired subassemblies including bias and erase controls, high-frequency suppression filter (to prevent the bias current from affecting the volume indicator reading) and a high-frequency post-equalizer.

The latter is used in the monitor circuit to complement a high-frequency pre-equalizer added in the recording circuit as described later.

Bias-Erase Oscillator. This new unit is added as a part of the system modification. It is a single-stage, push-pull oscillator employing two 6L6 Vacuum Tubes. In the output circuit a tuned filter provides an output signal having approximately 0.1% even harmonics. This prevents the introduction of objectionable noise and distortion due to an unsymmetrical bias or erase signal. Since the output control potentiometer is in the common cathode circuit, the

total plate drain varies with the signal level. By this means the plate drain is reduced from approximately 75 milliamperes for bias plus erase, to 30 milliamperes for bias only. The oscillator is capable of providing a maximum load current of 275 milliamperes at an output voltage of approximately 65 volts.

Pre-Equalizers and Recording Circuit. The low-frequency pre-equalizer has an 8-db peak at 60 cycles per sec. The high-frequency pre-equalizer is the conventional one used for many years in many Hollywood studios which has a 12-db rise at the high frequencies. The use of these two equalizers increases the effective signal-to-noise from approximately 50 db to approximately 58 db. Complementary low-frequency post-equalization in the monitoring circuit is obtained by properly selecting the low-frequency shelf-point for the 6 db per octave reproducing equalizer. A high-frequency post-equalizer is provided in the monitor circuit of the recorder control and mixer units.

A general purpose amplifier such as is used as a mixer and booster amplifier is provided to operate into the magnetic recorder head. This is preferable to utilizing the standard limiting amplifier because of its lower noise level and more gradual overload characteristic. However, the limiting amplifier is retained to operate the volume indicator and direct monitor circuits in the normal fashion, which greatly simplifies the circuit changes required when transferring between the two types of operation. For magnetic operation the limiting action is disabled and the peak-chopping level is set to its maximum value in order that it will affect only the occasional, short-duration overloaded peaks.

The added components, consisting of bias-erase oscillator, low- and high-frequency pre-equalizers and magnetic recording amplifier, can either be mounted in the console or cabinet of a particular system or may be assembled in a small portable cabinet with patching facilities for connecting to any system as required.

Since the modifications made in the standard system include transfer of power from the light meter and noise-reduction unit, no additional power unit is required when connecting the special magnetic facilities.

The magnetic modification facilities described herein have made available to the industry an immediate and economical means of utilizing existing studio equipment for both experimental and production magnetic recording.

Experimental investigations will allow the studios to familiarize themselves with this new medium and to assess its technical and economic value as applied to their particular production requirements.

Production experience with this modified equipment will also form the basis for the establishment of design requirements for the equipment which will eventually be made available for the magnetic recording of sound for motion pictures without the encumbrances of photographic recording facilities.

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Sprocketless Synchronous Magnetic Tape

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Summary—**Advantages inherent in the normally thin, narrow magnetic tape may be realized with a new method of obtaining true synchronism with film for motion pictures. Adaptability of the system to dubbing and post-synchronization is described. For television sound, it offers wide-frequency response and long playing time.**

Although often the bane of his existence, sprocket holes have nevertheless been a boon to the motion picture engineer since Edison's day. All motion picture equipment has been built around the sprocket hole; and then, of necessity, very thorough effort has been made to eliminate sprocket-hole flutter. Quite naturally, therefore, when magnetic recording showed its great possibilities, the first thought was to coat normal sprocket film base with magnetic coating, substitute magnetic heads for light valves and phototubes and carry on largely with the normal equipment. A very complete discussion of this approach has been given in the Journal.[1] There are also several other Journal articles of interest.[2] Concentrated efforts have also been made to place a narrow strip of magnetic coating on normal photographic stock so that the sound could be recorded on this strip, while the rest of the film carried the normal picture. This appears to be the ultimate system for prints.

Narrow magnetic tape has come to the fore. It is only .002 in. thick and has definitely established its position in sound reproduction. Its very thinness may hold some of the secret of its success; and, of course, the quarter-inch width makes for lighter and more compact reels. The application of this thin tape to synchronized operation has been so well developed that it is now successful in a practical manner. Also, during this development other advantages of this method of operation have been discovered, and these will be described.

This new system is independent of slippage and possible stretch of the sprocketless tape; these exist and perhaps always will. Furthermore, even if the tape drive were perfect, that of the motion picture film is not; it depends on the frequency of the power driving the cam-

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era motor. This may vary from instant to instant and day to day. What is really essential is not absolute speed regulation, but relative uniformity of speed between tape and film. As some form of registered control is absolutely essential, this system without actual perforations uses what might be termed "magnetic sprocket holes." They actually are magnetic recording of the pulses of the power driving the camera at the same time that the sound is being made. Normally this is 60-cycle power, so on the tape this power frequency is recorded simultaneously with the sound that is to accompany the pictures being shot. This power-frequency recording will then be used as a control to keep projector and tape in step for subsequent reproduction.

One immediate advantage that this method of registering control gives is that it is unnecessary to work with any kind of speed control in the tape recording other than the normally smooth advance of the tape accomplished with the aid of the synchronous motor-driven capstan of the tape machine. A good recording is assured with normally engineered tape equipment.

The sound recording on the tape is accomplished with normal magnetic heads, shown as the center three of the five of Fig. 1. These three are the "Erase" to clear the tape of any previous recording, then the "Record" which puts down the normal sound recording, and finally the "Playback" which gives the immediate playback to monitor the recording and then the final playback for recording. It is to be noted that all of these heads are magnetic toroids with the gaps in the toroids extending vertically across the tape. As the magnetism varies in these heads the tape will be correspondingly magnetized longitudinally, *i.e.*, in the direction of travel of the tape.

Now come the two control heads. The one on the left, which the tape traveling to the right first hits, is the "Playback Synchronizer." The one on the right is the "Record Synchronizer." It will be noted that, although these are also toroids, they are oriented at right angles to the other three; and this places their gaps in line with the tape movement. The magnetic effect in the tape with which they are concerned will therefore be up and down or vertical to the tape movement. This reorientation makes it possible to put the control signals on the tape without interfering with the normal sound recording, for two reasons: first, the control signal is made in a very narrow band in the center of the tape; and second, with its magnetism at right angles to the normal sound magnetism, the effect is definitely minimized. Actually it is possible to adjust the relative angles of the heads to ob-

tain this minimum; and normal sound level will be well above 50 db stronger than the remanent control signal which is picked up by the normal "Playback" head.

A large portion of motion picture work is made "double system," one equipment for the picture, the other for the sound; so here there is virtually no additional equipment necessary for tape sound instead of film sound. As a matter of fact, the tape sound equipment is lighter

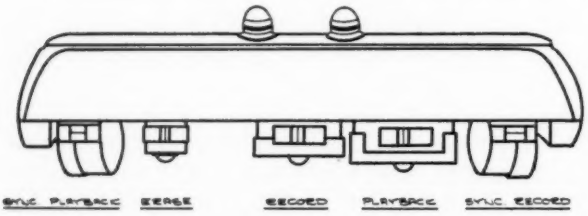

Fig. 1. Arrangement of magnetic heads.

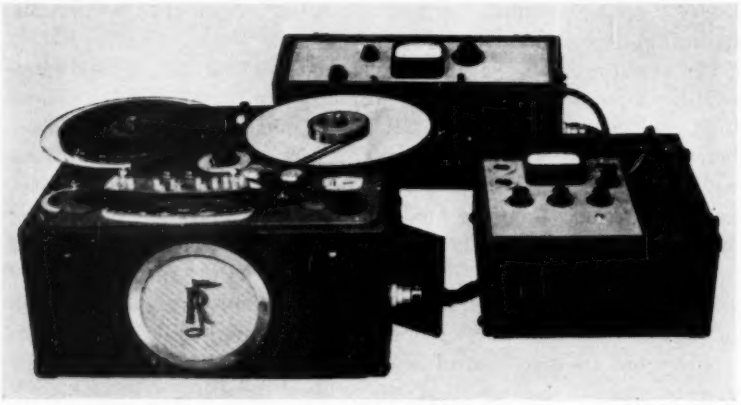

Fig. 2. Field unit, with recorder and microphone pre-amplifier.

than most sound film equipment. Furthermore, and here is the next big advantage of the tape, enough for an hour's steady recording can be readily accommodated in the tape reel.

On location the sound man sets up his portable equipment (see Fig. 2) about twenty-five feet away from the camera. A cable goes to the pre-amplifiers from which three microphones may be controlled with high-level mixing, earphones and VU meter. A preliminary run is made on the sound without the camera, and the director is able to call for a playback immediately to judge the quality and placement. After

this first test, it is usual for the sound man to run the tape back to the start and then be ready for the next, or real, take. This will erase what has been previously recorded. But after this first test, it is never wise or necessary to go back and erase any subsequent takes. That they are "Out-Takes" is just noted on the log, and the next take proceeds. It is of course wise to have blind track made on the scene, to have the normal background noises for subsequent splices which will then give good uniformity with the normal background noise. Also, these "Out-Takes" can often save the day by giving replacement material to substitute for some extraneous noise which may have gotten into what would otherwise be a good take. It is well to save everything once recording starts.

Incidentally, it is interesting to note that this synchronizing technique lends itself to all magnetic tape recorders of this variety. To adapt an instrument for this work, a synchronizing record head and associated circuits for recording the sixty cycles are simply added to the recorder. The recorder operates in its normal way otherwise.

Editing and splicing tape are relatively simple; there is no blooping problem. Also no attention need be paid the "magnetic sprocket holes." The greatest possible error in splicing them would be one-half a cycle which is less than one-quarter of a frame. The law of averages produces advances half the time and delays the rest, and to date no noticeable discrepancy has been discovered in an accumulated frame error from this source. Two continuous music sequences may be spliced without any noticeable bloop in the sound, although it is better for cadence values to make splices in silent portions.

When the takes have been assembled, they are then ready for dubbing to sound negative film. It is, naturally, best to run through the sequences to furnish the sound engineer, who is to do the dubbing to film, a chance to determine his dynamic values and frequency equalization before the film is exposed. The series of sequences is then run through as quickly as the series of film reels may be changed. The frequency range available from the tape is from 40 to 15,000 cycles, so that the dubbing engineer has a great chance to get the maximum out of the recording onto the film. Some very successful full orchestral selections have been made by this process.

To synchronize the tape to the film recorder, two methods are available. The first is to take the control signal recordings from the tape, amplify them sufficiently to control a thyratron inverter, shown in Fig. 3. This inverter gives 250 watts at the exact frequency of the control signals on the running tape. If this energy is delivered to the

film recorder, the sprocket holes of the film in this recorder will be advanced in strict accord with the magnetic control on the tape, so that perfect synchronism results.

Another method is to compare the control signals coming off the tape with the 60-cycle power then being used to drive the film recorder. This comparison may be made automatically in a bridge ar-

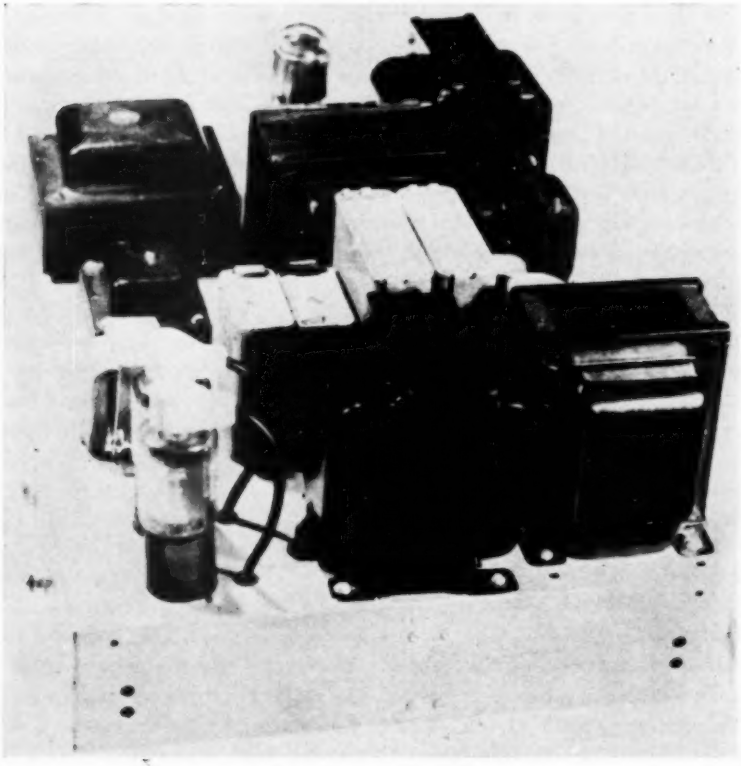

Fig. 3. Thyratron inverter.

rangement operating on a vacuum reactance tube as given in Fig. 4. This reactance tube in turn controls the frequency of an oscillator tube set normally for 60 cycles. This oscillator tube then drives the thyratron inverter previously mentioned, but which is now used to drive the synchronous motor on the tape machine. If the signal on the tape happens to be exactly in step with the power frequency at

the moment, the bridge is balanced and the reactance tube does nothing to the oscillator. But if the tape gets ahead so that the control frequency on the tape is ahead of the power source, then the bridge becomes unbalanced to the point of slowing down the tape advance, until the control signals on the tape are exactly in step with the power frequency. The tape is moved ahead if it gets behind by the reverse process of course. It is necessary to make this control quite slow so that it will cause no "wow" in the sound. It has been found that if this correction is at a rate of less than one cycle in two seconds, no speed variation can be heard.

Post-synchronizing offers a very interesting application of tape for the sound. In this operation, the sound is recorded on tape with the best possible attention to microphone placement. For this work, the control signal is not put on the tape at this time as the cameras are not

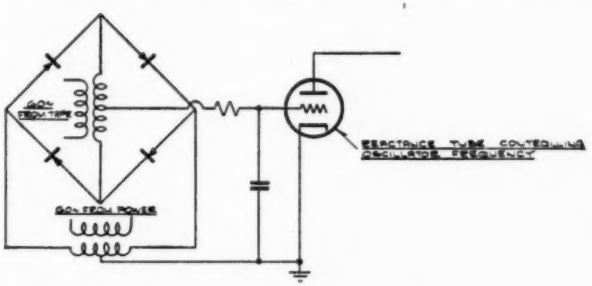

Fig. 4.

in action. Instead, the control signal is put on during the subsequent playback amplified to a loudspeaker to which the actors are performing for the cameras. So the control "Synchronizing Record" head is energized at the time that the cameras are likewise running in step with the 60-cycle power then in use. Thus, the control signal gets on the tape in step with the film for the pantomimed action. If long shots and close-ups are to be made from the same sound playback at different times, the synchronizing control signal is put on the tape during the long and usually continuous shot. Then the automatic control is used for the short close-ups to make the tape run in synchronism with the cameras then being used.

Tape has a third interesting advantage. With its flexibility, the tape may be made to accommodate or correct what often are slight errors in the timing of the actors playing to sound. For example, it was found that a very important orchestra always had a tendency to speed up over its first rendition of a given piece when it was perhaps

straining a bit to keep in strict step with the sound; therefore, after several attempts, the engineer simply speeded up the tape very slightly on the playback for camera action and the net result was perfect.

This may be carried a step further in a method that has already been tested, namely, a good musician controls the speed of the tape on playback and keeps the tape sound in step with that of the orchestra. This relieves the orchestra and the conductor of any strain in trying to do a double job themselves. So the orchestra and the conductor carry on in their normal manner after once having got the start from the loudspeaker playback, and the musician at the controls does the rest.

Now, as for dubbing: in this case the picture is made first and the sound subsequently recorded from the actors who are following the film pictures as they are projected. Tape now shows a fourth advantage. First, any number of tries may be made without wasting recording stock—and everyone knows that it is only with extreme difficulty that a perfect job can be accomplished, no matter how many the tries. But with tape, discrepancies may be corrected. For this purpose, loops of tape and picture film are made. As good as possible a take of the sound with the picture is made. The control signal is on the tape for this sound, and it is in step, supposedly with the film. But at certain portions the sound is a trifle late or early. (It is much worse if it is early. Distance gives a customary lag.) So the tape should be advanced or retarded to correspond. As is noted in Fig. 1, the "Synchronizing Playback" head comes first in the head assembly. So with the automatic control on, this head will see to it that the tape moves forward in step with the film. An indicator on the front of the Automatic Synchronizer control indicates Frame Advance or Retard from Zero accord, as shown in Fig. 5. But the automatic control may be thrown off when desired, and manual adjustment be substituted. Then the tape may be moved forward or back an appropriate number of frames. The operator tries this in dry runs until he makes the two agree very nicely, then he registers the new control once and for all. To do this, he goes through the same manual control, but turns on just the "Synchronizing Record" head.

Unpremeditatedly, it has turned out that this construction of "Synchronizing Record" head and the type of control signal put down on the tape may be overridden very completely by a second application of energy to this same head. So, in effect, a previous control signal may be completely replaced with a new one when desired. There-

fore, as the operator advances or retards the tape by frames, the new control signal is registered with the energy turned into this head, and thereafter automatically controlled playback will keep to this new step. Furthermore, if slight additional correction is necessary the process may be repeated.

Just one precaution: it is necessary when making such manual changes to be sure to come back to zero frame deviation at the end of the tape loop, so that the next run-through of the loop will start with the film. Also, another advantage of the positioning of the "Synchronizing Record" in the succession of heads gives the operator his reaction time to make the frame change slightly after he has observed the necessity for it. The separation between these end heads is 7½

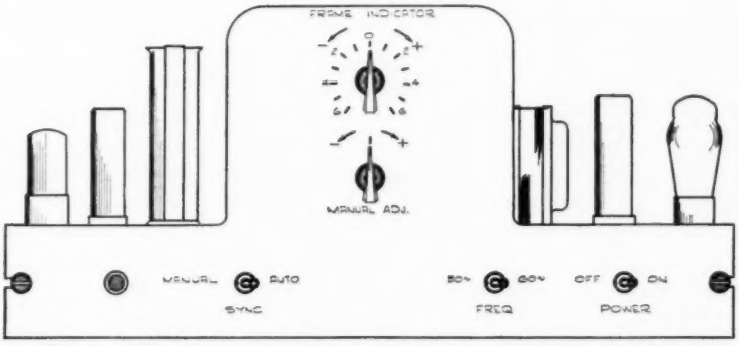

Fig. 5. Manual or automatic control unit for synchronous tape drive.

in., so at 15 in. a second, the normal tape speed, he has half a second to make the change indicated. The net result is that he can do it very smoothly.

Sound for television gives tape a fifth advantage. A double system of operation may be used for simultaneous transmission of pictures from film and sound from tape. Tape with its top frequency capability of 15,000 cycles offers full range to the FM sound transmission of television. Furthermore, it is no problem at all to run a straight half-hour of sound from tape, synchronized with the film.

The methods of starting tape and film together are to be noted. One method is to have normal start marks on tape and film, to place the film in the projector at this start mark on the film and to use a strip of metal foil stuck to the back of the tape at the start mark on the tape to start the film projector. The tape is started with a short leader ahead of this metal foil. Then when the tape is up to speed, along

comes this foil strip which makes a brief connection with a contact on the tape machine, and this closes a relay which starts the film projector. The time that it takes the projector to come up to speed is fairly regular, and it can be calibrated once and for all so that repeated starts may be made by this process without difficulty.

Another similar method for making the start also uses a leader on the tape ahead of the start mark. This leader has control signals on it for all but the last inch of the leader ahead of the start mark. A sensitive relay in the amplified output of the control signal operates on the control signals, and then when the momentary halt in them comes along, the sensitive relay drops back on its back contacts and the projector relay is set for this condition to get its start, so that then off both go together. Subsequent operation of the sensitive relay will have no effect on the projector relay, so that any momentary changes in the control signal will not affect the operation.

If at any time it becomes apparent to the operator that the tape needs to be advanced or retarded with respect to the film because of an error in threading or editing, something which he can become very expert in observing, the automatic synchronizing lock may be thrown off, and the framing be adjusted by hand smoothly during operation.

Shows are now being televised in which tape is used alternately with live program, with excellent uniformity between the two methods of presentation. This makes feasible a new type of program.

Tape is making real advances in its application to the motion picture field. Some of these have been most unexpected, and there is every reason to believe that as more people become acquainted with its potentialities, other uses will develop.

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A New $f/1.5$ Lens For Professional 16-Mm Projectors

By W. E. SCHADE

Eastman Kodak Co., Rochester, N.Y.

Summary—**To meet the growing demand for improved high-aperture 16-mm projection lenses, the Eastman Kodak Co. has announced a new series of $f/1.5$ lenses primarily intended for professional projectors. The lens is fundamentally of the Petzval type with field flattener. The resolving power, contrast and back focus clearance are substantially greater than in present designs. The paper includes a historical outline of the development of lenses of this type, showing the progressive improvements in aberration correction that have been attained in recent years.**

One hundred and nine years ago, one year after Louis Jacques Mande Daguerre (1787–1851) had announced the first practical process of photography, the daguerreotype, another important contribution to the new science, was introduced. Joseph Petzval (1807–1891), a professor of higher mathematics at the University of Vienna who had undertaken the design of a new lens for photographic purposes, was ready to present the results of his computations, the famous "Portrait Lens" (Fig. 1). The performance of the new lens, because of its excellent correction of spherical aberration and coma in combination with the unusually high aperture of $f/3.4$, was of such outstanding quality that it became the most prominent lens in the studios of all photographers. Besides the photographers, other groups, such as the manufacturers of optical instruments, as well as the contemporary opticians showed great interest in the new lens. The theoretical opticians of that time were impressed mainly by Petzval's new methods of lens design. His theories concerning aberrations, astigmatism and curvature of field were indeed new, and his theorem, the well-known "Petzval Sum" $\left(\frac{1}{R_p} = -\sum\frac{\phi}{n}\right)^*$ has been

* R_p is the radius of field curvature near the axis of the optical system when it is free from astigmatism; and

ϕ is the surface power $\left(\frac{n' - n}{r}\right)$ where n' and n are the indices of refraction and r the radius of curvature.

Presented: October 14, 1949, at the SMPE Convention in Hollywood.

Fig. 1. Original Petzval Portrait Lens (1840)

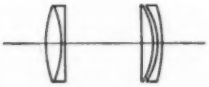

Fig. 2. Dallmeyer (1866) Zincke-Sommer (1870)

Fig. 3. Voigtländer (1878)

Fig. 4. Kodak Projection Lens $f/1.6$ (1935)

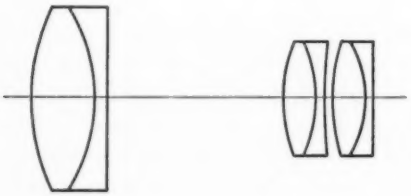

Fig. 5. Kodak Projection Lens $f/1.4$ (1939)

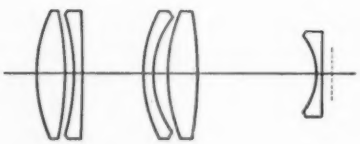

Fig. 6. M. V. Rohr (Zeiss) (1911)

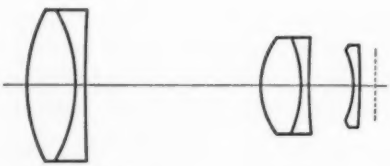

Fig. 7. Kodak Projection Ektanon $f/1.6$ (1938)

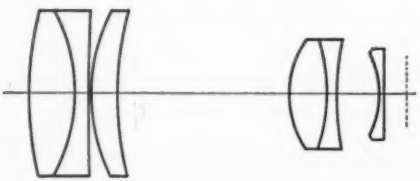

Fig. 8. Kodak Projection Ektar $f/1.5$ (1949)

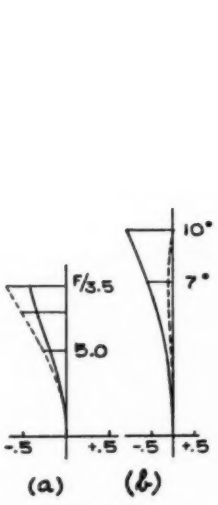

Fig. 3

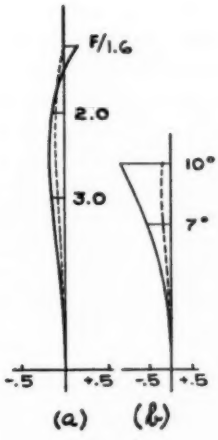

Fig. 4

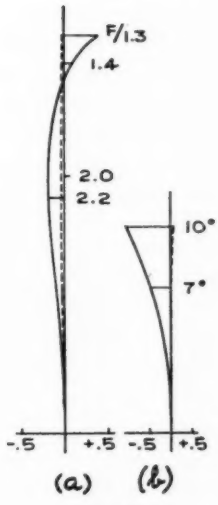

Fig. 5

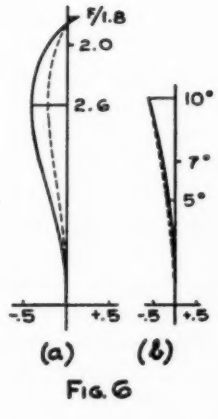

Fig. 6

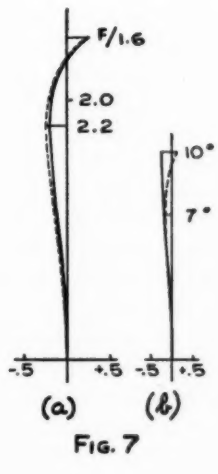

Fig. 7

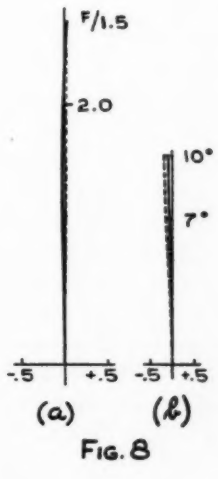

Fig. 8

Curves of spherical aberration, focal length differences and field curvatures for the lenses shown in Figs. 3 to 8 on the opposite page.

an important "tool" to lens designers ever since. It has been said that with Petzval the era of serious lens design had begun.

For twenty-five years the "Portrait Lens" was without any rival. Finally, in 1866 J. H. Dallmeyer[1] entered the competitive field with a modification of the Petzval lens, which was followed in 1870 by Zincke-Sommer with a similar design (Fig. 2). The modifications of the original Petzval lens consisted mainly in the reversed arrangement of the two single lenses composing the rear component. However, both designers were successful in increasing the relative apertures to $f/3$ and $f/2.37$ respectively.

In 1878 Voigtländer[2] was granted a German and a British patent based on a further modification of the Dallmeyer and Zincke-Sommer designs. He had succeeded in eliminating the airspace in the second component, and claimed that his lens, having only four air-glass surfaces against six in the other portrait lenses, would transmit more light and therefore render clearer images (Fig. 3).

The spherical aberration (full line) and the focal length difference (dotted line) of this Voigtländer $f/3.5$ lens for a focal length of 100 mm is indicated in Fig. 3a. The under-corrected spherical aberration, however, could be easily reduced and would then be closely comparable to that of the original Petzval lens.

The field curvatures for a focal length of 100 mm are shown in Fig. 3b. The meridional field (dotted line) is flat, but the sagittal field (full line) is curved.* The longitudinal separation between the two fields, the astigmatism, increases rapidly with obliquity.

With the approach of cinematography, it was this lens type that was selected to be used as a projection lens for 35-mm, 16-mm and 8-mm projection. Its merits of high contrast and excellent definition in and near the center, combined with simplicity and reasonable cost of manufacturing, have tempted many optical designers[3] to increase its usefulness with respect to higher relative apertures with improved aberrations and field curvature.

Such a lens is the Kodak Projection lens shown in Fig. 4. It is of the Petzval–Voigtländer type with a relative aperture of $f/1.6$. The spherical aberration (Fig. 4a) is small and the meridional field is flat (Fig. 4b). The performance of this lens is satisfactory. A lens of 2-in.

* The meridional field is determined by oblique rays which enter the optical system in the plane of the drawing.

The sagittal field is determined by oblique rays entering the optical system in a plane perpendicular to the plane of the drawing.

focal length, which is the standard for 16-mm projectors, resolves[4] about 100 lines/mm in the center, gradually falling off to about 20 lines/mm in the corner of the 16-mm frame, at a semi-angle of $6\frac{1}{2}°$.

Another recent modification[5] is the Kodak Projection lens $f/1.4$. To attain a relative aperture higher than $f/1.6$ the designer divided the second component into two, and was thus able to increase the relative aperture to as high as $f/1.3$. The spherical aberration, as shown in Fig. 5a, for an aperture of $f/1.4$ is small and the field characteristics are the same as those of the examples, Figs. 3 and 4. The lens was especially designed to be used in focal lengths longer than 2 in. A lens of 3-in. focal length will resolve 90 lines/mm in the center and 40 lines/mm in the corner of the 16-mm frame. The projected image is of high contrast and also free from lateral color and distortion.

The Field Flattener

As early as 1874, the British astronomer Charles Piazzi Smyth (1819–1900) invented an ingenious device for flattening the curved field of the Petzval portrait lens.[6] He placed a negative lens of sufficient power in the focal plane of his portrait lens and achieved a great improvement in the field curvature and covering power.

M. Von Rohr, the well-known historian, reports that the photographs taken by Smyth with his Petzval–Smyth lens combination were of remarkable quality. For many years Smyth's simple but noble device seems to have been forgotten, or to say the least, neglected. In the year 1911, Von Rohr[7] (Carl Zeiss) introduced a lens combination comprising a portrait lens to which a negative field-flattener lens was attached near the focal plane (Fig. 6).

His design differs from the original Smyth arrangement in several ways. In order to obtain a useful back-focus clearance, he had to design the entire system as a unit, because when the field flattener is moved away from the exact focal plane, it immediately begins to affect all the aberrations of the main lens. To obtain another degree of freedom in his work of design, he introduced an airspace between the two elements of the front component of the portrait lens and was able to achieve a relative aperture as high as $f/1.8$. The lens consists of five single elements, separated by air. The spherical aberration (Fig. 6a) is well corrected, but the zone ($f/2.6$) shows a considerable amount of residual under-correction. Instead of flattening at least the meridional field, the designer seemed to be more interested in freedom from

astigmatism with the result that both fields were curved. Nevertheless, the improvement over the original Petzval portrait lens is immense.

The Smyth principle has been applied in the well-known Kodak Projection Ektanon lens,[8] shown in Fig. 7. It consists of the modified Petzval type and a field flattener, with a relative aperture as high as $f/1.6$. The aberrations (Fig. 7a) are such that this lens of 2-in. focal length resolves 90 lines/mm in the center of the projected image. Astigmatism and the curvatures of the meridional and sagittal field (Fig. 7b) show a considerable improvement over the lenses without the field flattener, and consequently there is a more satisfactory performance. A lens of 2-in. focal length will resolve 50 lines / mm in the corner of the 16-mm frame.

THE NEW PROJECTION EKTAR LENS

The progressive improvement of lenses of the Petzval type, especially those embodying a field flattener, has been described in the previous paragraphs.

However, the demand for a 16-mm projection lens, comparable with the best used in 35-mm projection, is steadily increasing. Next to a high relative aperture it is imperative that the resolving power of such a lens should be of a higher order than ever before. These requirements have led to a new design, the Kodak Projection Ektar $f/1.5$ (Fig. 8).

This lens is fundamentally of the modified Petzval type to which a field flattener has been attached. To surpass the performance of previous projection lenses, the designer has not only added one element to the front component to reduce the zonal spherical aberration, but has also taken advantage of the new high-index glasses[9] of which elements 3 and 4 consist.

The zonal spherical aberration (Fig. 8a) has been reduced to a minimum. Astigmatism and field curvatures (Fig. 8b) also show a distinct improvement which has to be credited to the use of high-index low-dispersion glasses. These have already proved their value in other optical systems.[10] In the present case the use of these glasses relieves the field flattener of some of the burden of Petzval sum correction. In this way the flattening of the sagittal field (formerly the worse offender) has been solved satisfactorily. The relation of the two fields to one another is such that, by a slight bending of the field flattener, astigmatism could be brought to zero with both fields flat. However,

since the entire oblique pencil had to be considered and the oblique spherical aberration had shown a tendency to over-correction, a slight inward displacement of the sagittal and meridional focal points was necessary.

Fig. 9. A series of Projection Ektars.

The performance of this lens is indicated in the curves in Fig. 8a and 8b. It resolves better than 90 lines/mm over the entire 16-mm frame with a perfectly flat field. With respect to contrast, the lens has

proved to be a worthy descendant of its famous ancestor, the Petzval lens.

It was decided to manufacture a series of these $f/1.5$ Projection Ektar lenses in 2.062-in. barrels, the focal lengths being in geometrical progression as originally recommended by Rayton.[11] The choice of common ratio was based on the decision to allow two intermediate lenses to fall between the standard 2-in. and 3-in. sizes. The new focal lengths thus became $2\frac{1}{4}$ and $2\frac{5}{8}$ in., at a common ratio of about 12% (Fig. 9). If this series were continued one step further in the long direction it would fall at $3\frac{1}{2}$ in., but it was felt that this is probably too long for most civilian applications. However, longer sizes can, of course, be made if required.

In every case, the resolving power of 90 lines/mm has been rigidly maintained in manufacture, over the entire area of a flat 16-mm projector gate.

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(2) F. von Voigtländer, Ger. Pat. 5761 (1878) or equivalent Br. Pat. 4756 (1878).

(3) W. H. Repp, U.S. Pat. 1,479,251 (1922); A. Warmisham, U.S. Pat. 1,484,853 (1922); C. Graf, U.S. Pat. 1,610,514 (1925); R. Richter, U.S. Pat. 1,843,519 (1931); and A. Warmisham, Br. Pat. 485,096 (1936).

(4) R. Kingslake, "Resolution tests on 16 mm projection lenses," *Jour. SMPE*, vol. 37, pp. 70–75; July, 1941.

(5) W. Schade, U.S. Pat. 2,158,202 (1939).

(6) W. Merté, R. Richter, and M. von Rohr, *Das Photographische Objectiv*, pp. 10–11; Springer, Wien, 1932.

(7) W. Merté, R. Richter, M. von Rohr, *Das Photographische Objectiv*, pp. 326, 329; Springer, Wien, 1932. For other lenses embodying a field flattener, see: H. D. Taylor, Br. Pat. 127,058 (1917); A. Warmisham, Br. Pat. 492,311 (1937); and F. W. Gehrke, U.S. Pat. 2,187,780 (1938).

(8) D. Wood, U.S. Pat. 2,076,190 (1934).

(9) R. Kingslake and P. F. De Paolis, "New optical glasses," *Scientific Monthly*, vol. 68, p. 420; June, 1949.

(10) G. H. Aklin, "The effect of high index glasses on the field characteristics of photographic objectives," *Jour. SMPE*, vol. 38, pp. 841–844; October, 1948.

(11) W. B. Rayton, "A proposed new series of standard focal lengths for motion picture projection objectives," *Jour. SMPE*, vol. 15, pp. 270–280; July, 1930.

The Metal-Diazonium System For Photographic Reproductions

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Summary—The metal-diazonium system for photographic reproduction, which has been developed in Philips Laboratory in Eindhoven in the course of the last few years, is based on the discovery that when a solution of a diazonium compound and a metal salt, say mercurous nitrate, is exposed to light, atomic metal — *in casu* mercury — is separated. The "latent" mercury image thus obtained can be transformed by physical development into a silver image and intensified. The light-sensitive system is obtained in the form of a film or sheet by impregnating a suitable carrier, say a strip of cellophane 40 μ thick, in a homogeneous solution of the said materials. The metal-diazonium system possesses an extremely high resolving power (> 1000 lines/mm) and allows of working with a very high gamma (6–8) while on the other hand low gammas (1–2) can also easily be obtained by varying external factors, *viz.* the moisture content or the intensity of exposure. The light-sensitivity of the system is in cellophane several times (in paper some tens of times) greater than that of the usual diazotype printing papers. This system, which was originally intended only for producing distortion-free copies of Philips-Miller sound film, lends itself excellently, *inter alia*, for the copying of picture-sound films, thanks to the external variability of the gamma. The impregnating of the cellophane base takes place on printing machines designed for the purpose, while at the same time these machines are fitted with a device for regulating the moisture content of the base. The good photographic properties of the system and the very low cost of materials open great prospects for its application on a large scale in all sorts of fields. In addition to the sound film and the picture-sound film also the field of micro and macro documentation is regarded as an important domain for the application of the system.

The metal-diazonium system is a new light-sensitive system that has been worked out by a group of scientists in the Philips Laboratory at Eindhoven. It possesses a number of remarkable properties making it exceptionally suitable for the photographic reproduction of pictures as well as of sound. Something has already been said about this system in a previous article,[1] where it was shown by a comparison with the usual methods of reproduction what place the new system could occupy.

Here we shall give a more detailed description of the fundamental

[1] C. J. Dippel and K. J. Keuning, "Problems in photographic reproduction, in particular of sound-films," *Philips Tech. Rev.*, vol. 9, no. 3, pp. 65–72; 1947.

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principles of the metal-diazonium system and after going more deeply into its properties show how it is realized and practiced, then concluding by dealing with a number of perspectives for the application of this new reproduction material.

PRINCIPLE OF THE SYSTEM

The Light-Sensitive Material

Diazonium salts have the general chemical formula

$$[R - N{\equiv}N]^{+}X^{-}$$

in which R is an aromatic radical and X some anion. These compounds have been used for quite a time already for photographic reproduction methods. They are most familiar and most widely used in diazotype, a light-printing process for the multiplication of technical drawings and suchlike (tracings) made on transparent material.

Just as with all reproduction methods based on diazonium compounds, the fundamentals of this light-printing process lie in the following properties:

(a) Coupled with certain phenols or amines, the diazonium salts form what are known as azodyestuffs.

(b) When a diazonium salt is exposed to light in the presence of water (water vapor) dissociation takes place and nitrogen is released. Schematically the reaction takes place as follows:

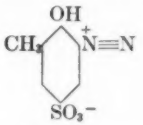
$$RN_2X + H_2O + h\nu \rightarrow \text{l.d.p.} + N_2 + HX. \qquad (1)$$

The light-decomposition product (l.d.p.) thus formed is no longer capable of forming a dyestuff. If, therefore, one exposes a "diazotype paper" on which a tracing is laid and then causes the reaction, (a) above, to take place, a dyestuff is formed only on those parts of the paper that have not been exposed to the light. In this way a positive copy is obtained direct from the tracing.

The difficulties and limitations referred to in the previous article[1] as being inherent in photographic reproduction with the usual silver-bromide and silver-chloride systems exist in a still higher degree with the diazonium processes hitherto known. They have not met with any appreciable success, for instance, in the reproduction of picture-sound films.

The new photo-chemical system described here is based on the discovery that the light-decomposition products obtained from certain diazonium compounds according to equation 1 are capable of releas-

ing the metal from suitable metal salts, for instance mercury from mercurous nitrate, gold from aurochloride, etc. As diazonium compound one may use for instance o-cresol-diazonium-sulphonic acid:



When an aqueous solution of this compound and, for example, mercurous nitrate, $Hg_2(NO_3)_2$, applied in a thin flat layer is exposed with light of a short wavelength (*e.g.* 3650 A) one may observe under the microscope small drops of metallic mercury at the places struck by the light. Thus a faint "mercury picture" is formed which might be compared to the "latent" picture in the usual method of photography with silver halogenides. And here, too, the "latent" picture can be intensified and made durable by developing. Contrary to the custom with silver halogenide photography, however, a so-called physical developing process is applied with our system. In view of the important part this developing method plays in the metal-diazonium system a separate section will be devoted to it below.

In order to show properly the difference from the old diazonium processes the point is stressed that only the second of the two characteristic properties of diazonium salts mentioned above, *viz.* the light decomposition, is utilized in the metal-diazonium system, the other property—formation of dyestuffs—playing no useful part in our system. The diazonium compound left on the unexposed parts is removed, while the exposed parts turn black (separation of metal). Thus we get instead of a positive copy a negative copy, as is the case with silver halogenides.

As to the practical realization of the system we shall revert to this later, but it is necessary to say something here about the manner in which the thin layer of the light-sensitive material is obtained. In this respect the new system differs fundamentally from the silver halogenide systems. With the latter systems an "emulsion" (more correctly: a suspension) of the light-sensitive substance, *e.g.* crystalline silver bromide, is made in gelatine and after a complicated and most precise ripening process this emulsion is cast on a celluloid film or a glass plate. In our case, on the other hand, a homogeneous solution is made of the diazonium compound and the metal salt and a suitable carrier is saturated with it. As carrier one may use for

instance paper or, as we have done in the most important applications, a transparent base of regenerated cellulose. This latter material (which is more commonly known under the name of cellophane and is widely used as packing material for shop goods) is used by us in the form of a reel of film 0.04 mm (0.0016 in.) thick. But in principle one may also use with our system a gelatinous layer on celluloid or glass. One may also use the cellulose acetate film (so-called safety film) commonly applied for substandard films and by saponification make the surface suitable to absorb the aqueous solution of our light-sensitive system.

Physical Developing Process

What takes place in the so-called physical developing process in photography may be resolved into a phenomenon often met with in nature and in technology and which might be described as follows. When particles from an over-saturated solution or vapor begin to precipitate they show a preference for places where certain "nuclei" are present. If these nuclei are distributed locally in such a way as to form a "picture," maybe so faint that the eye cannot see it, then the picture is intensified by this selective precipitation of particles and may thereby be made visible.

A familiar phenomenon known to everyone is the picture formed by condensation on a smudged glass window when the window is breathed upon or cold air blows upon it from one side, water vapor condensing on the traces of dirt acting as nuclei and making visible figures.[2] Another example that may be given is that of the Wilson camera, where droplets of water from an oversaturated vapor condense on electrically charged particles and thus make visible the path followed by an ionizing particle.

Turning particularly to photography, we see that both chemical and physical developing methods are in use, the latter more particularly in cases where negatives have to be intensified. Let us first consider what ordinary chemical developing comprises. A silver bromide film or plate is placed in a developing bath containing a reducing agent, for instance metol or hydrochinon, in a generally alkaline solution. The grains of silver bromide, in which silver nuclei have

[2] In the familiar game of writing or drawing on a glass window with a wet finger, when some days later the writing is made visible by breathing upon it, we have examples of negative pictures; the window is more or less uniformly covered with "dirt," which is removed by the finger (or at least partly so) or else a thin film of grease is left behind, so that less vapor is condensed on the writing than on the rest of the window.

been formed by the exposure (groups of say 100 atoms of metallic silver), are reduced by the developer entirely to silver, while the unexposed or too weakly exposed grains remain untouched. After this developing, as is known, the remaining silver bromide is removed with the aid of sodium thiosulfate (fixing).

If the picture thus obtained is not dense enough, it can be intensified by physical development. The film is placed in a weak acid solution containing silver nitrate in addition to a reducing agent, for which metol or hydrochinon can again be used. In the solution the silver nitrate is gradually reduced to silver, the solution becoming oversaturated, as it were, with atomic silver, which precipitates preferably on those places where "silver nuclei" are already present, *i.e.* on the exposed parts of the film.[3]

It is perhaps of interest to note that this physical developing process can be applied also to the "latent," not yet chemically developed, image on the exposed silver bromide film. One can start by fixing the exposed film, thus removing all the silver bromide and leaving only the silver nuclei formed by the exposure, the latter then acting as nuclei for the subsequent physical development as described above.

The oldest photographic process, daguerreotype, was likewise based upon a physical method of developing; an image was formed on an iodized silver plate and the exposed plate was treated with oversaturated mercury vapor. Mercury was thereby condensed on the exposed parts of the plate and the picture became visible.

After these examples the method of physical developing applied with the metal-diazonium system does not need much more explanation. The carrier, containing for instance o-cresol-diazonium-sulfonic acid and mercurous nitrate, is placed after exposure in a suitable solution of silver nitrate and a reducing agent. Reaction then takes place between the locally formed metallic mercury and the silver nitrate, the mercury dissolving and silver precipitating at those places, the latent mercury picture thus being transformed into a latent silver picture. Moreover, by reduction metallic silver is gradually formed in the solution. The local metal deposits already present act as nuclei upon which more and more silver is deposited as new silver is formed in the solution, thereby developing the picture.

[3] In this case the physical developing process comprises also a chemical process. From this it appears that the name "physical development," which we use because it has already been introduced, does not express the essential difference from the actual chemical process of developing. The difference as we see it lies in the fact that in chemical development the metal from which the picture is built up is already present in the appointed place prior to developing in any form whatever, whereas in the physical development it is only brought into its appointed place by the developing process.

One of the essential factors in this process is the rapidity with which the silver is formed in the solution by reduction. If this takes place very rapidly one gets instead of a selective deposit a more or less evenly spread deposit of silver, a phenomenon that can even be turned to advantage for making homogeneous silver mirrors. By giving the solution, for instance, a suitable degree of acidity one can regulate the speed of the spontaneous reduction of the silver nitrate and cause practically all the silver formed during the developing process to precipitate on the nuclei of the picture, to the exclusion of almost all undesired precipitation of silver on the unexposed parts. The negative may not be kept in the developing bath longer than the time taken for developing, because the developer is an unstable system and liable in time to cause a spontaneous flocculation of all the silver, which then precipitates anywhere.

We will not conclude this explanation of the principles of the metal-diazonium system without remarking that here only a very rough and greatly simplified representation of the processes has been given. To understand the connection between the photographic properties obtained and the numerous variable factors of the system it has been necessary to study deeply the mechanism of the light decomposing reaction (equation 1) and of the developing process. It may be possible at a later date to go more deeply into the problems arising, some of which are still unsolved.

PROPERTIES OF THE METAL-DIAZONIUM SYSTEM

Resolving Power

In the article previously quoted[1] it was explained that for photographic reproduction, especially of picture-sound films, a high resolving power is favorable. However, there is a limitation in this respect, in that it tends to spoil the quality of reproduction (unsharp pictures, distortion of high frequencies); or, when trying to avoid this drawback, it necessitates a greater length of film (the picture may not be too small), the same applying for the speed of the film on account of the sound.

The positive films commonly used for copying picture-sound films have a resolving power of between 50 and 75 lines/mm, so that when projecting gratings finer than what corresponds to this number of lines per mm the lines run into each other and therefore can no longer be made visible separately. Some new Kodak films for special

purposes have a resolving power as high as 160 lines/mm. *The metal-diazonium system is quite capable of resolving 1000 lines/mm.* It is even possible that its resolving power is still greater, for the optical means used in determining this power have themselves a limited resolving power, which in our case did not reach further than the said limit of 1000 lines/mm.

In other laboratories too, *i.a.* Kodak, it has for some time been possible to make reproductions with an extremely high resolving power, of the order of 1000 lines/mm.[4] Collodion plates or so-called Lippmann emulsions are used. Except for the already known application of wet collodion plates for making autotypes, as far as we know none of these processes has been suitably developed for general use.

The high resolving power of the metal-diazonium system is due for a large part to the fact already mentioned that the light-sensitive material is not used in the form of an emulsion but in that of a homogeneous solution; the unexposed system is quite free of grains, so that there is very little diffusion of light in the sensitized material. If a large quantity of light reaches one point then in the circle round about that point where undesired light reaches, owing to diffusion, the quantity of that light is extremely small. Moreover, and this is the second cause of the high resolving power, that circle (the diffusion halo) remains extremely small owing to the fact that with the chosen concentration of the chemical components in the light-sensitive solution the active light is very strongly absorbed. Consequently the diffused light does not reach far.

Owing to the strong absorption the direct light thrown upon the carrier upon exposure stays in the top layer. Consequently the metal forming the picture is limited to a thin layer. This is likewise of importance for the high resolving power, for it is not sufficient that details are recorded well separated in the carrier—they must also be reproduced separately either for copying or for projection. Owing to the fact that one never uses perfectly parallel light beams, the thicker the picture layer the more details are lost.[5]

[4] See, for instance, *J. Sci. Instr.*, vol. 18, pp. 66–67; 1941, where an account is given of the "Kodak maximum resolution plate," which can resolve 600 or even 1200 lines/mm. Similar results have been reported by H. Frieser, *Z. wiss. Phot.*, vol. 40, p. 132; 1941. For older methods, see E. v. Angerer, *Wissenschaftliche Photographie*, p. 136 *et seq.* Akad. Verl. Leipzig, 1931.

[5] Also in the old diazotype processes based on diazonium compounds the material is free of grains, but the resolving power is not very high, because, *i.a.*, the picture is rather thick: owing to the relatively small absorption a thick layer of dyestuff is necessary for adequate "density." Furthermore the formation of the dyestuff is a relatively slow reaction, so that after the exposure a noticeable diffusion takes place before the (fixed) molecules of the dyestuff are formed.

Figure 1, the magnified reproduction of a micro-document made with the new system, demonstrates the high resolving power.

The Gamma Value

Every photographic picture, be it positive or negative, has a certain characteristic density curve which indicates the density obtained for any exposure $E = I \cdot t$ (I luminous intensity, t exposure time). The density D[6] is usually plotted as a function of $\log E$; see for instance Fig. 2. For many light-sensitive materials the density curve shows a

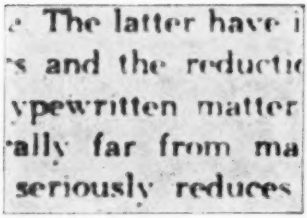


Fig. 1. A reproduction, linearly enlarged about 250 ×, of a piece of a micro-document recorded with the metal-diazonium system in cellophane. The size of this piece in the micro-document was 0.012 × 0.017 cm and the height of the letters 12 microns. The good definition of the reproduced letters gives an idea of the exceptionally high resolving power of the system (> 1000 lines/mm).

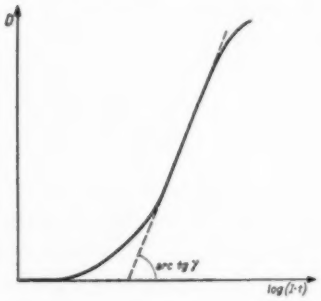


Fig. 2. Example of a density curve $D = f(\log I \cdot t)$ of a photographic picture. The maximum slope of the curve lying in the practically rectilinear part in the middle is the gamma.

more or less extended, practically rectilinear part, where at the same time the slope of the curve is greatest. The whole curve is in fact characterised by this slope, the gamma, because this is decisive for the gradation in the reproduced picture (reproduction of the shades of brightness). It is well known that with the usual silver halogenide systems the value of the gamma depends largely upon the emulsion and is further particularly determined by the conditions of developing (temperature and composition of the developing bath, time taken in developing). Common values in practice vary from 0.5–2.5.

When applied in a suitable manner, as will be defined below, the

[6] Defined as $D = \log i_0/i$, where i is the portion of an incident quantity of light i_0 that the blackened plate or film allows to pass through.

metal-diazonium system has very *much higher gammas, e.g. 6–8.* In the previous article[1] it has been explained what important advantages this offers for instance for sound reproduction. Since with a high gamma a relatively small reduction in the exposure intensity is sufficient to bring about a transition from the "greatest density" to the "smallest density," only the innermost part of the circle diffusion halo already referred to is noticeably blackened. Thus the high gamma promotes a high resolving power and therefore in the case of sound reproduction promotes good reproduction of the high frequencies. The high gamma yields particular advantages in the copying of Philips-Miller film, as we have seen in the previous article; the "lens effect" arising in this process is rendered harmless without any other measures being necessary.[7]

External Variability of the Gamma

In sound reproduction by the amplitude system, advantage can safely be taken of a high gamma, because in principle we have only to do with two densities, a very low one in the transparent sound track and a very high one for the rest of the film. There are all sorts of other applications where the same holds, *e.g.* in micro and macro documentation, to be discussed below. In picture reproduction, on the other hand, a whole series of shades of brightness (half tones) has to be reproduced by corresponding, continuously varying densities. To attain this it is necessary to satisfy the Goldberg condition,[8] as a result of which in picture reproduction one has to work with relatively low gammas, *e.g.* 1.5–2.5.

Now such gammas and still lower values can be obtained quite easily with the metal-diazonium system. This is possible not only by a suitable choice of the composition of the system but also by making use of the following important feature: *the gamma of a metal-diazonium-cellophane system can be greatly influenced by the moisture content of the film during exposure and likewise by the duration of the exposure.* The very high gammas referred to under the previous heading occur

[7] Also the so-called wedge effect with the Philips-Miller film is rendered harmless by the high gamma. When the transparent sound track in a "Philimil" film is cut with the wedge-shaped chisel, which is a characteristic feature of the Philips-Miller system, an oblique edge is left on the top layer, and when copying this results in a gradual transition from the maximum to the minimum density. In itself this does no harm, but aberrations arise if there is any variation in the thickness or the density of the covering layer. The higher the gamma, the narrower this edge transition shows on the copy and the smaller the aberration.

[8] See the explanation in the article quoted in footnote 1.

when the cellophane film is dry, that is to say when its moisture content is not more than say 15% by weight, and when the film is exposed with a great intensity (and corresponding short exposure time). If the moisture content is increased to 25–30% by weight, then one gets the low gammas required for good picture reproduction.

Figure 3 indicates the relation between the gamma value and the moisture content of a cellophane film for certain concentrations of the ingredients and under certain conditions of exposure, developing, etc. There the following refinement has been applied. Instead of showing the gamma indicating the maximum slope of the density curve, the values g_1, g_2, g_3 have been plotted of the average slope that the density curve assumes in three consecutive density intervals of

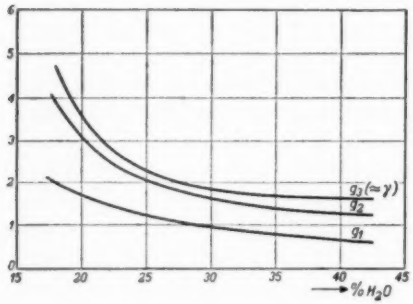


Fig. 3. Effect of the moisture content of the cellophane film upon the gamma of the mercury-diazonium system in the film for a certain concentration of the ingredients and a certain manner of exposure and developing. The lines plotted represent the average slopes g_1, g_2, g_3 of the density curve in three different density areas; g_3 is practically equal to the maximum slope γ.

the most importance in practice, *viz.* between $D = 0.05$ and 0.5 (high lights); $D = 0.5$ and 1.0 (intermediate tones); $D = 1.0$ and 1.5 (shadows). The value g_3 is generally practically equal to the maximum slope defined as γ.

This defined description of the gradation, often applied with silver halogenide systems and sometimes even extended to five intervals, is desired when one has a group of density curves which do not all have a rectilinear part with maximum slope in the density area required. This is also frequently the case with the metal-diazonium-cellophane system, with which it is possible to get a large variety of density curves under the influence of the numerous variables.

The fact that the gamma, or in other words the density curve, depends upon the duration of exposure t means that the density D is no longer a function of the product $I \cdot t$ but of I and t separately. Therefore instead of a two-dimensional density curve, to describe fully the photographic behavior of the system we need a solid figure in which the curved plane $D = f(I, t)$ is represented. Such a plane is drawn in perspective in Fig. 4. It must be borne in mind that by

varying the moisture content, the conditions of developing, etc., a different plane is obtained every time. The "density curve" of a picture taken with an exposure time t_1 is the cross section of the density plane parallel to the D and I axes which is intersected by the t axis at t_1. From Fig. 4 it is clearly seen that for different values of t one obtains density curves with a different slope (gamma). A number of these curves are drawn in Fig. 5, while in Fig. 6 the slopes g_1, g_2, g_3 ($\approx \gamma$) of these curves are plotted as a function of t.

From this it also follows that the relation between $\log I$ and $\log t$ for a constant density D (horizontal cross sections of the curved plane at different heights; see Fig. 4) is given by lines the slope of which must gradually change with varying D. Whereas in the simplest case, which was assumed in Fig. 2, D was only a function of $I \cdot t$ so that for the given D we had $\log I + p \log t = \text{constant}$ with $p = 1$, in our case as a rule $p \neq 1$. This is the familiar Schwarzschild effect. Moreover, according to the foregoing, in our case the Schwarzschild exponent p (slope of the $\log I$-$\log t$ lines in the area where these may be regarded as straight) depends also upon the density.

Figures 3 and 6 give a clear picture of the great variability of the gamma in the metal-diazonium system. Now it is important to note that this is an *external variability:* on one and the same material and with one developing process we can make copies with a high gamma and with a low gamma. This creates not only the possibility already mentioned of copying both sound and pictures each with the most favorable gamma, but also an entirely new possibility of copying sound and picture side by side on one film and developing them together without necessitating a compromise in the gamma such as is characteristic for the present picture-sound film technique (see the previous article[1]). All that is necessary is either to select the exposure intensities separately for the copying of the pictures and for the copying of the sound track, or else to vary the moisture content of the cellophane band between the two places where in the printing machine first the picture is copied and farther on the sound track is copied (it may be that both measures have to be applied together).

In a similar manner we can also print on one film the pictures of different scenes with a different gamma while requiring only one developing process! This offers the possibility of correcting any exposure or developing variations in the negatives.

Light Sensitivity

The light sensitivity of the metal-diazonium system depends not only upon the choice of the ingredients, etc., but also varies with dif-

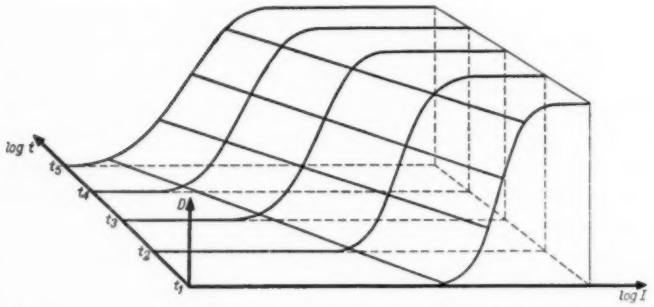


Fig. 4. The gamma of the metal-diazonium system also depends, *i.a.*, upon the intensity of exposure I. Therefore the density D is not fully determined by the product $I \cdot t$; the photographic behavior of the system has to be described by a solid density plane $D = f(I, t)$. This plane is drawn here for given concentrations, moisture content, developing, etc., in perspective. Log I and log t are plotted as independent variables.

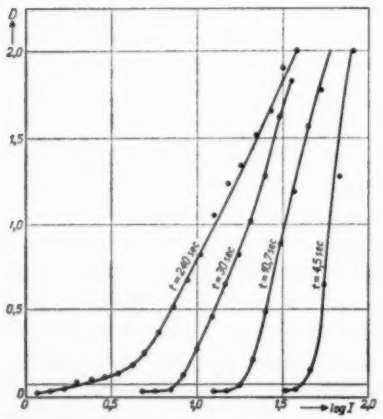


Fig. 5. From the density plane drawn in Fig. 4 it is possible to find for any exposure time t the density curve $D = f(I)$ of the picture obtained with that exposure time, by taking a cross section of the plane perpendicular to the t-axis at the level of that time. Such cross sections are represented here for various exposure times. It is seen that curves are obtained with different slopes (different gammas).

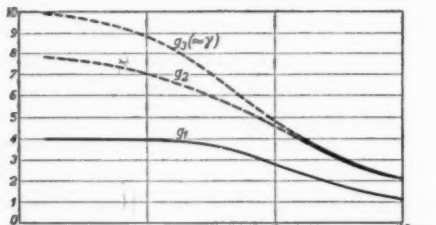


Fig. 6. The slopes g_1, g_2, g_3 of the curves of Fig. 5 plotted as functions of the exposure time t.

ferent carriers. When cellophane is used the sensitivity may be several times greater than that of the known diazotype papers. Yet with paper as a carrier the sensitivity of the system is greater by a factor of 10. For instance with mercury as metal the metal-diazonium paper can easily be made 20–25 times as sensitive as the positive diazotype papers, a gain which just makes it possible to produce enlargements by the light-printing process (see the last section). Still this is a factor 10^4 below the sensitivity of silver bromide enlargement papers.

There is, therefore, no question that the metal-diazonium system as at present developed could compete with the materials commonly used for photographic recording. As a matter of fact the spectral zone in which the metal-diazonium system is sensitive is too limited for this purpose. The sensitivity of the mercury-diazonium system lies mainly in the near ultraviolet with a maximum in the vicinity of 3900 A and not extending beyond the bluish green (about 5000 A).

For application as reproduction material, however, in most cases neither the low sensitivity nor the limitation of the spectral area constitutes any objection. One only needs to use for the copying process a light source possessing great luminous intensity in the said range of the ultraviolet. Super-high-pressure mercury lamps with water cooling are excellently suited for this purpose. With these lamps the intensity of light that can be reached when exposing the film is so great that a film can be copied at fairly great speeds, for instance 20 meters per minute.

An important advantage of the limited spectral sensitivity lies in the fact that the whole working of the system can take place under a bright sodium light, since in the wavelength range of the sodium lines (5890 A) the sensitivity is practically nil.

A great deal of work has been done in this laboratory in respect to the question as to what determines the sensitivity of the metal-diazonium system. In the particular case where mercury is employed as a metal it was demonstrated that the process of the formation of the latent mercury picture has a quanta yield of about 50%; for an average of two exposure quanta one atom of metallic mercury is formed. This means that the "primary" sensitivity is of the same order as that of the silver halogenide systems. According to the conclusions provisionally reached from an investigation into the highly complicated mechanism, the cause of the so much smaller resulting sensitiveness of our system is to be sought rather in the further history of the nuclei to be developed; the metallic atoms combine to form larger particles. As already stated, under a very strong magnification (about 800 ×) these particles may be seen in the latent picture. Thus in this stage the metal is rather coarsely dispersed and in the physical developing process the resultant density is all the less according as the (given) quantity of metal of the latent picture is more coarsely distributed.

The influence of the moisture content and the intensity of the exposure upon the gamma is also closely related to the history of the primary metallic atoms and of the metallic nuclei prior to developing.

Durability

When talking of durability in the case of the metal-diazonium system we have to differentiate between the exposed and the unexposed state. The unexposed system appears to have as yet too little durability for a sensitized cellophane film, for instance, to be kept in stock until one has need of it. For the most important applications that we have in mind, however, this forms no serious objection, as will be made clear below.

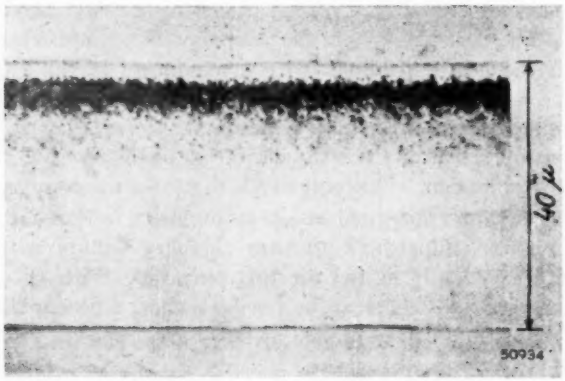


Fig. 7. Microtome cross section of a sensitized cellophane film 40 microns thick after exposure and developing. The particles of silver from which the picture is built up lie in a thin layer a few microns below the surface.

After exposure and developing one has a picture that will keep practically indefinitely: as already mentioned above, the definitive picture consists of metallic silver, just as is the case with silver halogenide systems, and thus is perfectly proof against atmospheric influences and light (such contrary to the dyestuff pictures of the old diazotype papers). Furthermore, the picture on a cellophane film is protected in a peculiar manner against mechanical damage: when a microtome section of such a film is cut and examined under the microscope it will be seen that the extremely thin layer containing the metallic silver of the image (see above) does not lie on the surface of the film but a few microns below it; see Fig. 7. We cannot go into the ex-

planation of this here, but it has the welcome practical advantage that the actual picture is protected against scratching, etc., by the thin layer of clear cellophane covering it.

Economy

It is to be expected that the cost of the metal-diazonium system will be relatively low, a factor that will prove to be of great weight for various applications. How is it that the system turns out to be so economical? In the first place there is the choice of the carrier, cellophane being the cheapest material imaginable for this purpose. Another important factor is the limited consumption of silver, it being a characteristic of the physical developing method that the sensitive material itself need not contain any silver; the silver comes from the developer and is added to the negative, and the developing can be so controlled that not much more silver need be used than is necessary for building up the ultimate silver picture. With the usual silver halogenide systems, on the other hand, a very high percentage of silver is wasted; it comes out of the exposed film in the fixing bath and cannot be recovered except at considerable expense.

Of further importance is the very simple method of manufacture, as will be explained under the next heading.

Yet another advantage to be mentioned in connection with the economy of the metal-diazonium cellophane system is the saving in volume and the attendant ease of storage and transport. A cellophane film 40 microns thick and say 300 m long winds up into a reel about 13 cm in diameter, whereas a normal celluloid film of 300 m length forms a reel 26 cm in diameter.

REALIZATION OF THE METAL-DIAZONIUM SYSTEM

The metal-diazonium system can be realized in quite different ways according to the use intended and the carrier employed. As a typical example we will consider here the application of the system for the copying of picture-sound films with cellophane as the carrier.

Just as is the case with the common silver bromide films, so with the cellophane film the actual copying process takes place on a machine where both the negative and the positive films are caused to pass along under a lamp simultaneously. Now we have already said that the cellophane film is sensitized by impregnating it in its entirety with the solution containing the light-sensitive system. Further it has been stated that the cellophane film sensitized in this manner has only

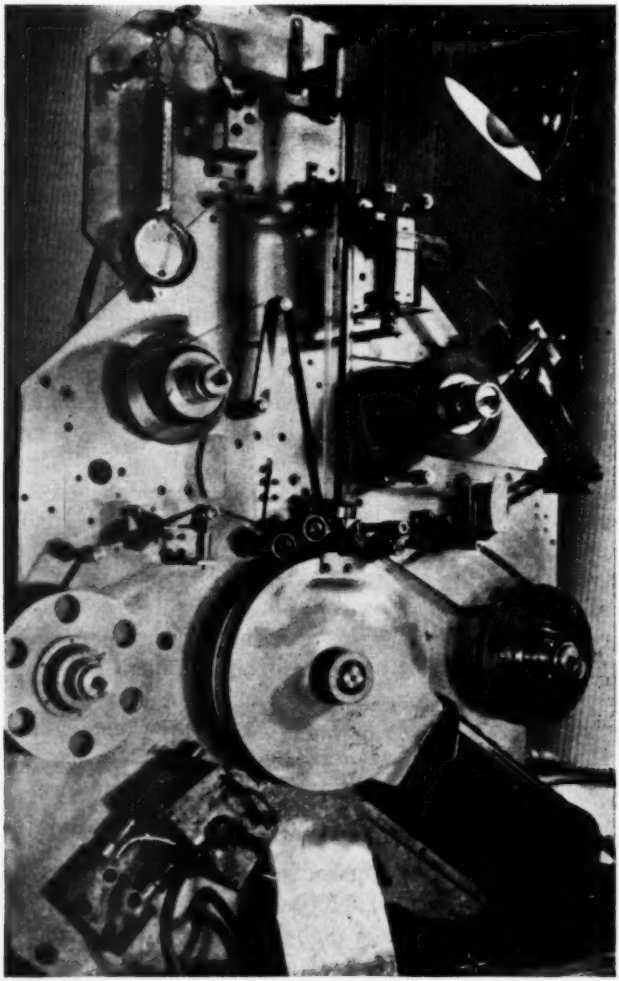


Fig. 8. Printing machine on which a cellophane film is first impregnated in the light-sensitive solution, then dried to the desired moisture content and after that exposed. The film is fed in from the right, impregnated in the bath at the top on the right, dried in the vertical tube and printed on the drum in the middle at the bottom of the photo, where it is brought into contact with the original film to be copied, the two films passing underneath the lamp simultaneously. (For drying the film when running at a high speed several tubes were used; with the latest machine drying is done by high-frequency heating.)

a limited durability. The difficulties that this might involve have now been overcome in a very simple way by *combining the sensitizing process with the printing process*, the impregnating of the cellophane film and the exposure taking place on the same machine in succession.

The fact that we have here an extremely simple and economical *modus operandi* is quite evident when comparing it with the manufacture of silver bromide film, where the preparation of the carrier, the preparation and ripening of the emulsion, the casting of the emulsion on the celluloid film and later the copying are all done in separate departments.

The first mentioned method has also been found to improve considerably the reproducibility of the properties of the film.

Between the impregnating and the exposing of the cellophane film this has to be dried to a moisture content corresponding to the desired gamma. Further, it must be possible to reduce still further the moisture content between the exposure of the picture and that of the sound track on the film if such should be desired. This can be done by passing the film through a tube with conditioned air, as seen in Fig. 8, or by means of high-frequency heating.

POSSIBILITIES OF APPLICATION

The system is still too young to allow of any data being given as to its applications, but the experience so far gained with it opens such interesting perspectives that a brief outline of some of its possible uses may well be given here.

Sound Film

A stereophonic sound track has been made on 7-mm cellophane films by copying a stereophonic Philips-Miller film.[9] Thanks to the sharp definition of the mechanically recorded original and the high resolving power of the copying material an exceptionally good quality of sound is obtained, in respect to the reproduction of the high frequencies and the absence of nonlinear distortion (see the article quoted in footnote[1]). This good quality of reproduction together with the enhanced "naturalness" obtained by stereophony seem to us to constitute the requisites for imparting to "mechanical" music the original musical character.

[9] K. de Boer, "Stereophonic recording on Philips-Miller film," *Philips Tech. Rev.*, vol. 6, pp. 80–84; 1941.

Partly by reason of the low cost of the reproduction method, it is in principle possible that this ideal method of reproducing music will come within the reach of everyone for use in the home. An attraction of the cellophane films used for this method is that a music film with a playing time of one hour forms a reel no more than 18 cm in diameter (playing speed 32 cm per sec); see Fig. 9. This is

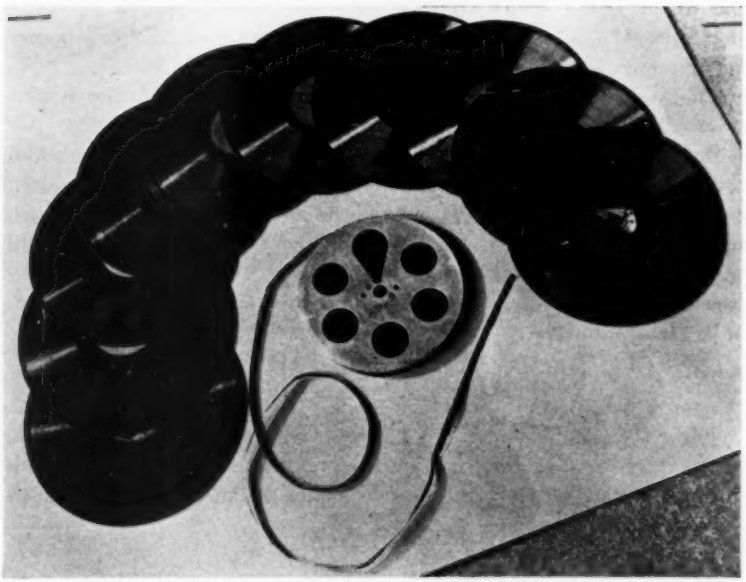


Fig. 9. An illustration of the compactness of a recording of music on cellophane film. Music that takes one hour to play can be recorded stereophonically on a film reel of the size of that shown in the illustration. For the same playing time (without stereophony!) 10 gramophone records of 25 cm diameter are required.

due on the one hand to the extreme thinness of the cellophane film (40 microns) and on the other hand to the fact that it is possible to print on a 7-mm film two stereophonic sound tracks (thus in all four tracks).

A piece of music of one hour can be reproduced without any of the interruptions that are unavoidable with the gramophone even when using an automatic record-changer.

Picture-Sound Film

Apart from the cinema there is a wide field of possibilities awaiting the "talkies." Such could be used on a large scale for entertainment in the home, for educational purposes in schools, for advertising, etc., provided they are cheap and of good quality. The 8-mm film, which would seem to lend itself best to this purpose, has not yet been widely used because it is still too expensive and owing to the limited resolving power of the common emulsions the pictures are not sharp enough; furthermore it does not leave any room for the sound track. Though the sound track is applied on a 16-mm film the quality of the sound reproduction is not all one would desire.

Now the metal-diazonium system as a copying material presents a situation that is more favorable in many respects: apart from the possibility of making a sound track even on an 8-mm film, on a 16-mm film a better sound quality can be obtained than has hitherto been possible, partly due to the high resolving power and partly by reason of the variability of the gamma. Both of these factors also help in improving the picture quality—as is clearly noticeable on a contact print of a very fine-grained film, *e.g.* Isopan FF—although a limit is set to the sharpness of the picture by the limited resolving power of the original film (about 55–75 lines/mm) and possibly of the optical system of the camera. Finally the film could be cheaper.

The same considerations apply for the copying of standard 35-mm films on the new system.

For playing the very thin cellophane films special projectors are required. Figure 10 shows a model of a home cinema equipped with such a projector. If normal projectors are still to be used then the metal-diazonium system will have to be applied in or on a thicker carrier (say 130 microns thick), but then of course one loses the advantage of the great compactness of film reels with a long playing time.

Micro-Documentation

Micro-documentation is a comparatively young branch of the technique of reproduction, but it seems that a surprising development may be expected in this very direction.

The name itself already expresses its meaning: the recording of documents on a very small scale. The need for this may be due to various reasons. In some cases it is resorted to because the documents are so bulky or would become so bulky as to constitute a problem for

their filing, storage, handling or transportation; examples are the catalogs of large libraries, card index systems of large telephone exchanges or of the registers of births, deaths and marriages in large cities, etc. There are other cases where micro-documentation is applied because reproduction on the normal scale is too expensive, as for instance

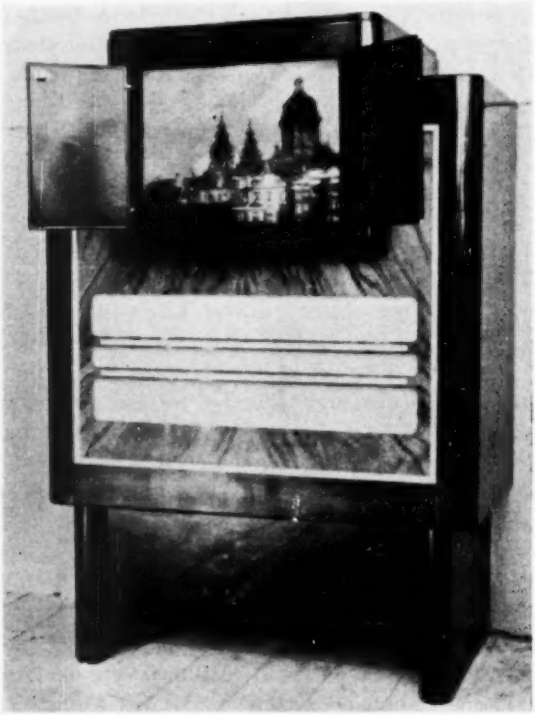


Fig. 10. Model of a home cinema fitted with a special projector (mounted in the cabinet) for cellophane film. The projected picture satisfies high requirements regarding sharpness as well as gradation.

the copying of publications by libraries, or for the air-mailing of documents where weight is a big consideration, etc.

Obviously the higher the resolving power of the material used for the photographic reproduction, the smaller the size of the reduced document. With the extremely high resolving power of our metal-diazo-

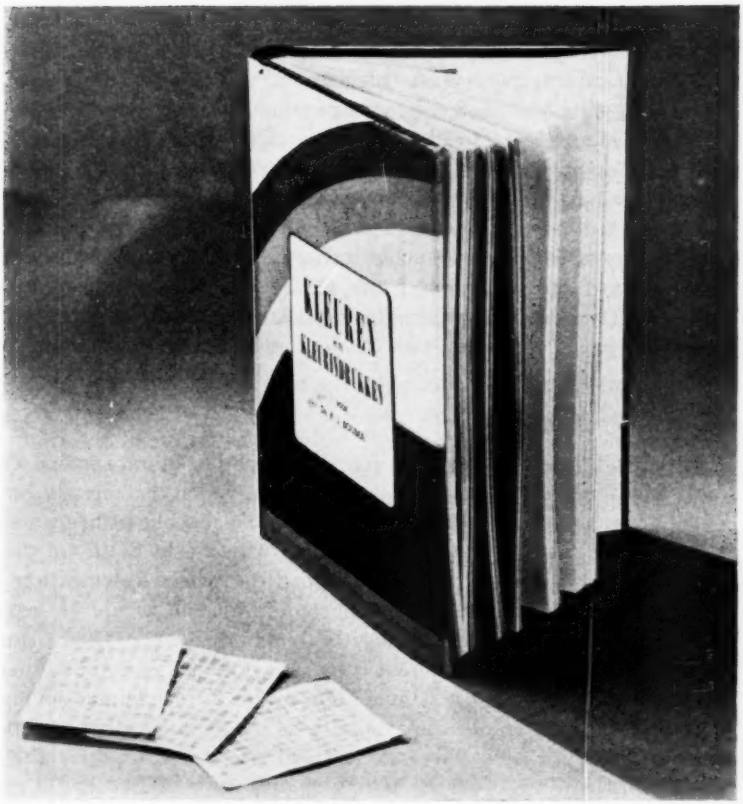


Fig. 11. Three small sheets of metal-diazonium paper on which the complete contents of a book of 330 pp. have been reduced. Each page of the book is reduced on the paper to a size of 5 × 7 mm. The reproduced book is quite legible with a simple reading apparatus.

nium system it is possible to make a perfect record of a whole page of printing of the size of an 8 × 11½ in. periodical on an area of 0.6 by 0.9 mm, the height of the letters being about 12 microns.

It cannot be predicted whether one will ever go as far as such an extremely small size with the present stage of development of microdocumentation. For the present the sizes of, for instance, 5 × 7 or 2 × 3 mm seem desirable.

If one keeps to the larger dimensions of say 5 × 7 mm per page then the high resolving power of the metal-diazonium system is not utilized to its fullest extent, but even so this material will prove to be of great advantage owing to its low cost. Large tabular works, encyclopedias, etc., which can now practically only be consulted in libraries, could be reproduced on such a small scale on this inexpensive material as to be brought within the reach of anyone having occasion to read such works from time to time. Micro-reproductions can be read with a simple reading apparatus. The saving in volume is astonishing, even with the relatively large size of 5 × 7 mm, for a series of large books totaling 10,000 pages can be reduced to a pocket-size booklet of 100 pp. Three such pages, compared with the original normal book, are shown in Fig. 11.

Macro-Documentation

As the last field of application for the metal-diazonium system we would mention that of macro-documentation, which has already become of common usage in the form of diazotype and blueprinting and photocopying directly on a legible scale. Owing to the nature of the documents to which this process is applied (drawings, specifications, etc.), for this purpose the metal-diazonium system would be employed in paper. The paper is sensitized on both sides, so that it can be used on both sides for different copies; it does not curl up, and on account of its two-sided use it sometimes means a considerable saving in volume. Furthermore the image (a silver picture) gives a very rich contrast, with a pleasant tone (neutral grey), and is quite stable, properties which are often so lacking in diazotype and blueprinting processes. Of particular importance, however, is the possibility of making enlargements with metal-diazonium paper with exposure times that are practicable (for instance 1–5 seconds, depending upon the size). Thus we get a very efficient working method: wherever such is desired on account of frequent use, documents recorded on a micro-film can be enlarged again on metal-diazonium paper.

Proposed Bylaw Amendment

THE PROPOSED AMENDMENT to the Society's Bylaws that appears on the following pages was approved by the Board of Governors at its January 31st meeting, and is now ready for consideration by the voting members of the Society. At a Business Meeting now scheduled for the Opening Session of the 67th Convention in Chicago on April 24th, members will be asked to submit their comments or criticisms of the proposal and then vote on the adoption of the Amendment. If approved, the Amendment will take effect at once and will be published with the Constitution in the May issue of the JOURNAL.

This is the second basic alteration of the rules governing the Society to be considered as a result of a three-year study of the Constitution, Bylaws and Administrative Practices. The first, developed early in 1949, produced the Constitutional Amendment, including the change of the Society's name, discussed at the Annual Business Meeting on October 10th in Hollywood, and subsequently approved by the voting membership for adoption as of January 1, 1950.

A special Committee on Revision of the Constitution and Bylaws was authorized by the Board of Governors and first appointed on January 23, 1947, by then President, Loren L. Ryder. It has been continued by President Earl I. Sponable and will now turn its attention to the task of preparing a parallel revision of the Administrative Practices.

The guiding principle in this work has been that of eliminating excess verbiage, together with a careful defining of committee procedures and responsibilities, where necessary. Examples of the effect of this reappraisal are the recent changes in organization of certain engineering committees, adopted on recommendation of J. A. Maurer, former Engineering Vice-President, and F. E. Carlson, Chairman of the Standards Committee. Greater responsibility for preparatory work on standards has been placed on members of the Standards Committee, which is now made up largely of chairmen of the several engineering committees.

Members are urged to compare the following proposed Amendment with the present Bylaws, last published in the JOURNAL in April, 1949, p. 463. The recent Constitutional Amendment, including the change of name, last appeared, in the form as finally adopted, in the September, 1949, JOURNAL, p. 306. All voting members who can arrange to attend the April 24th Business Meeting are encouraged to do so and are invited to discuss freely the merits of the following proposal:

BYLAWS OF THE SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS

BYLAW I

MEMBERSHIP

Sec. 1. Membership of the Society shall consist of the following grades: Honorary members, Sustaining members, Fellows, Active members, Associate members and Student members.

An *Honorary member* is one who has performed eminent service in the advancement of engineering in motion pictures, television, or allied arts. An Honorary member shall be entitled to vote and to hold any office in the Society.

A *Sustaining member* is an individual, company, or corporation subscribing substantially to the financial support of the Society.

A *Fellow* is one who shall be not less than thirty years of age and who shall by his proficiency and contributions have attained to an outstanding rank among engineers or executives of the motion picture or television industries. A Fellow shall be entitled to vote and to hold any office in the Society.

An *Active member* is one who shall be not less than twenty-five years of age and shall be or shall have been either one or an equivalent combination of the following:

(a) An engineer or scientist in motion picture, television or allied arts. As such he shall have performed and taken responsibility for important engineering or scientific work in these arts and shall have been in the active practice of his profession for at least three years, or

(b) A teacher of motion picture, television or allied subjects for at least six years in a school of recognized standing in which he shall have been conducting a major course in at least one of such fields, or

(c) A person who by invention or by contribution to the advancement of engineering or science in motion picture, television or allied arts, or to the technical literature thereof, has attained a standing equivalent to that required for Active membership in (a), or

(d) An executive who for at least three years has had under his direction important engineering or responsible work in the motion picture, television or allied industries and who is qualified for direct supervision of the technical or scientific features of such activities. An Active member shall be entitled to vote and to hold any office in the Society.

An *Associate member* is one who shall be not less than eighteen years of age, and shall be a person who is interested in the study of motion picture or television technical problems of connected with the application of them. An Associate member is not privileged to vote, to hold office or to act as chairman of any committee, although he may serve upon any committee to which he may be appointed; and, when so appointed, shall be entitled to the full voting privileges on action taken by the committee.

A *Student member* is any person registered as a student, graduate or undergraduate, in a college, university, or other educational institution of like scholastic standing, who evidences interest in motion picture or television technology. Membership in this grade shall not extend more than one year beyond the termination of the student status described above. A student member shall have the same privileges as an Associate member of the Society.

Sec. 2. All applications for membership or transfer should be made on blank forms provided for the purpose, and shall give a complete record of the applicant's education and experience. Honorary and Fellow grades may not be applied for.

Sec. 3. (a) Honorary membership may be granted upon recommendation of the Honorary Membership Committee when confirmed first by a three-fourths majority vote of those present at a meeting of the Board of Governors, and then by a four-fifths majority vote of all voting members present at any regular meeting or at a special meeting called as stated in the bylaws. An Honorary member shall be exempt from the payment of all dues.

(b) Upon recommendation of the Fellow Award Committee, when confirmed by a three-fourths majority vote by those present at a meeting of the Board of Governors, an Active member may be made a Fellow.

(c) An Applicant for Active membership shall give as references at least two mem-

bers of the grade applied for or of a higher grade. Applicants shall be elected to membership by a three-fourths majority vote of the entire membership of the appropriate Admissions Committee. An applicant may appeal to the Board of Governors if not satisfied with the action of the Admissions Committee, in which case approval of at least three-fourths of those present at a meeting of the Board of Governors shall be required for election to membership or to change the action taken by the Admissions Committee.

(d) An applicant for Associate membership shall give as reference one member of the Society, or two persons not members of the Society who are associated with the motion picture, television, or allied industry. Applicants shall be elected to membership by approval of the Chairman of the appropriate Admissions Committee.

(e) An applicant for Student membership shall be sponsored by a member of the Society, or by a member of the staff of the department of the institution he is attending, this faculty member not necessarily being a member of the Society. Applicants shall be elected to membership by approval of the Chairman of the appropriate admissions committee.

Sec. 4. Any member may be suspended or expelled for cause by a majority vote of the entire Board of Governors, provided he shall be given notice and a copy in writing of the charges preferred against him, and shall be afforded opportunity to be heard ten days prior to such action.

BYLAW II

OFFICERS

Sec. 1. An officer or governor shall be an Honorary member, Fellow, or an Active member.

BYLAW III

BOARD OF GOVERNORS

Sec. 1. The Board of Governors shall transact the business of the Society in accordance with the Constitution and Bylaws.

Sec. 2. The Board of Governors may act on special resolutions between meetings, by letter ballot authorized by the President. An affirmative vote from a majority of the total membership of the Board of Governors shall be required for approval of such resolutions.

Sec. 3. A quorum of ten members of the Board of Governors shall be present to vote on resolutions presented at any meeting. Unless otherwise specified, a majority vote of the Governors present shall constitute approval of a resolution.

Sec. 4. A member of the Board of Governors may not authorize an alternate to act or vote in his stead.

Sec. 5. Vacancies in the offices or on the Board of Governors shall be filled by the Board of Governors until the annual elections of the Society.

Sec. 6. The Board of Governors, when filling vacancies in the offices or on the Board of Governors, shall endeavor to appoint persons who in the aggregate are representative of the various branches or organizations of the industries interested in the activities of the Society to the end that there shall be no substantial predominance upon the Board, as the result of its own action, of representatives of any one or more branches or organizations of such industries.

Sec. 7. The time and place of all except special meetings of the Board of Governors shall be determined by the Board of Governors.

Sec. 8. Special Meetings of the Board of Governors shall be called by the President with the proviso that no meeting shall be called without at least seven days prior notice to all members of the Board by letter or telegram. Such a notice shall state the purpose of the meeting.

BYLAW IV

ADMINISTRATIVE PRACTICES

Sec. 1. Special rules relating to the administration of the Society and known as Administrative Practices shall be established by the Board of Governors and shall be added to or revised as necessary to the efficient pursuit of the Society's objectives.

BYLAW V

COMMITTEES

Sec. 1. All committees, except as otherwise specified, shall be formed and appointed in accordance with the Administrative Practices as determined by the Board of Governors.

Sec. 2. All committees, except as otherwise specified, shall be appointed to act for the term served by the officer charged with appointing the committees or until he terminates the appointment.

Sec. 3. Chairmen of the committees shall not be eligible to serve in such capacity for more than two consecutive terms.

Sec. 4. Standing Committees of the Society to be appointed by the President and confirmed by the Board of Governors are as follows:

Honorary Membership Committee
Journal Award Committee
Nominating Committee
Progress Medal Award Committee
Public Relations Committee
Samuel L. Warner Memorial Award Committee

Sec. 5. There shall be an Admissions Committee for each Section of the Society composed of a chairman and three members of which at least two shall be members of the Board of Governors.

Sec. 6. There shall be a Fellow Award Committee composed of all the officers and section chairmen of the Society under the chairmanship of the Past-President. In case the chairmanship is vacated it shall be temporarily filled by appointment by the President.

BYLAW VI

MEETINGS OF THE SOCIETY

Sec. 1. The location and time of each meeting or convention of the Society shall be determined by the Board of Governors.

Sec. 2. The grades of membership entitled to vote are defined in Bylaw I.

Sec. 3. A quorum of the Society shall consist in number of 1/15 of the total of those qualified to vote as listed in the Society's records at the close of the last fiscal year before the meeting.

Sec. 4. The annual meeting shall be held during the fall convention.

Sec. 5. Special meetings may be called by the President and upon the request of any three members of the Board of Governors not including the President.

Sec. 6. All members of the Society in any grade shall have the privilege of discussing technical material presented before the Society or its Sections.

BYLAW VII

DUTIES OF OFFICERS

Sec. 1. The President shall preside at all business meetings of the Society and shall perform the duties pertaining to that office. As such he shall be the chief executive of the Society, to whom all other officers shall report.

Sec. 2. In the absence of the President, the officer next in order as listed in Article V of the Constitution shall preside at meetings and perform the duties of the President.

Sec. 3. The seven officers shall perform the duties separately enumerated below and those defined by the President:

(a) The Executive Vice-President shall represent the President, and shall be responsible for the supervision of the general affairs of the Society as directed by the President.

The President and the Executive Vice-President shall not both reside in the geographical area of the same Society Section, but one of these officers shall reside in the vicinity of the executive offices. Should the President or Executive Vice-President remove his residence to the same geographical area of the United States as the other, the office of Executive Vice-President shall immediately become vacant and a new Executive Vice-President shall be elected by the Board of Governors for the unexpired portion of the term.

(b) The Engineering Vice-President shall appoint all technical committees. He shall be responsible for the general initiation, supervision, and co-ordination of the work of these committees.

(c) The Editorial Vice-President shall be responsible for the publication of the Society's *Journal* and all other Society publications.

(d) The Financial Vice-President shall be responsible for the financial operations of the Society, and shall conduct them in accordance with budgets prepared by him and approved by the Board of Governors.

(e) The Convention Vice-President shall be responsible for the national conventions of the Society. He shall arrange for at least one annual convention to be held in the fall of the year.

Sec. 4. The Secretary shall keep a record of all meetings; and shall have the responsibility for the care and custody of records, and the seal of the Society.

Sec. 5. The Treasurer shall have charge of the funds of the Society and disburse them as and when authorized by the Financial Vice-President. He shall be bonded in an amount to be determined by the Board of Governors, and his bond shall be filed with the Secretary.

Sec. 6. Each officer of the Society, upon the expiration of his term of office, shall

transmit to his successor a memorandum outlining the duties and policies of his office.

BYLAW VIII

SOCIETY ELECTIONS

Sec. 1. All officers and governors shall be elected to their respective offices by a majority of ballots cast by voting members in the following manner:

Nominations shall first be presented by a Nominating Committee appointed by the President, consisting of nine members, including a Chairman. The committee shall be made up of two Past-Presidents, three members of the Board of Governors not up for election, and four other voting members, not currently officers or governors of the Society. Nominations shall be made by three-quarters affirmative vote of the total Nominating Committee.

Not less than three months prior to the Annual Fall Meeting, the Board of Governors shall review the recommendations of the Nominating Committee, which shall have nominated suitable candidates for each vacancy.

Such nominations shall be final unless any nominee is rejected by a three-quarters vote of the Board of Governors present and voting. The Secretary shall then notify these candidates of their nomination. From the list of acceptances, not more than three names for each vacancy shall be selected by the Board of Governors and placed on a letter ballot. A blank space shall be provided on this letter ballot under each office, in which space the name of any voting member other than those suggested by the Board of Governors may be voted for. The balloting shall then take place. The ballot shall be enclosed with a blank envelope and a business reply envelope bearing the Secretary's address and a space for the member's name and address. One set of these shall be mailed to each voting member of the Society, not less than forty days in advance of the annual fall meeting.

The voter shall then indicate on the ballot one choice for each vacancy, seal the ballot in the blank envelope, place this in the envelope addressed to the Secretary, sign his name and address on the latter, and mail it in accordance with the instructions printed on the ballot. No marks of any kind except those above prescribed shall be placed upon the ballots or envelopes. Voting shall close seven days before the opening session of the annual fall convention.

The sealed envelope shall be delivered by the Secretary to a Committee of Tellers appointed by the President at the annual fall convention. This committee shall then examine the return envelopes, open and count the ballots, and announce the results of the election.

The newly-elected officers and governors of the Society shall take office on January 1, following their election.

BYLAW IX

DUES AND INDEBTEDNESS

Sec. 1. The annual dues shall be fifteen dollars ($15) for Fellows and Active members, ten dollars ($10) for Associate members, and five dollars ($5) for Student members, payable on or before January 1, of each year. Current or first year's dues for new members in any calendar year shall be at the full annual rate for those notified of election to membership on or before June 30; one half the annual rate for those notified of election to membership in the Society on or after July 1.

Sec. 2. (a) Transfer of membership to a higher grade may be made at any time subject to the requirements for initial membership in the higher grade. If the transfer is made on or before June 30, the annual dues of the higher grade are required. If the transfer is made on or after July 1, and the member's dues for the full year have been paid, one half of the annual dues of the higher grade is payable less one half the annual dues of the lower grade.

(b) No credit shall be given for annual dues in a membership transfer from a higher to a lower grade, and such transfers shall take place on January 1, of each year.

Sec. 3. Annual dues shall be paid in advance.

Sec. 4. Failure to pay dues may be considered just cause for suspension.

BYLAW X

PUBLICATIONS

Sec. 1. The Society shall publish a technical magazine to consist of twelve monthly issues, in two volumes per year. The editorial policy of the *Journal* shall be based upon the provisions of the Constitution and a copy of each issue shall be supplied to each member in good standing mailed to his last address of record.

Copies may be made available for sale at a price approved by the Board of Governors.

BYLAW XI

LOCAL SECTIONS

Sec. 1. Sections of the Society may be authorized in any locality where the voting membership exceeds twenty. The geographic boundaries of each Section shall be determined by the Board of Governors. Upon written petition for the authorization of a Section of the Society, signed by twenty or more voting members, the Board of Governors may grant such authorization.

SECTION MEMBERSHIP

Sec. 2. All members of the Society of the Motion Picture and Television Engineers in good standing residing within the geographic boundaries of any local Section shall be considered members of that Section.

Sec. 3. Should the enrolled voting membership of a Section fall below twenty, or should the technical quality of the presented papers fall below an acceptable level, or the average attendance at meetings not warrant the expense of maintaining that Section, the Board of Governors may cancel its authorization.

SECTION OFFICERS

Sec. 4. The officers of each Section shall be a Chairman and a Secretary-Treasurer. The Section chairmen shall be ex-officio members of the Board of Governors and shall continue in such positions for the duration of their terms as chairmen of the local Sections. Each Section officer shall hold office for one year, or until his successor is chosen.

SECTION BOARD OF MANAGERS

Sec. 5. The Board of Managers shall consist of the Section Chairman, the Section Past-Chairman, the Section Secretary-Treasurer, and six voting members. Each manager of a Section shall hold office for two years. Vacancies shall be filled by appointment by the Board of Managers until the annual election of the Section.

SECTION ELECTIONS

Sec. 6. The officers and managers of a Section shall be voting members of the Society. All officers and managers shall be elected to their respective offices by a majority of ballots cast by the voting members residing in the geographical area of the Section. Not less than three months prior to the annual fall convention of the Society, nominations shall be presented to the Board of Managers of the Section by a Nominating Committee appointed by the Chairman of the Section, consisting of seven members, including a chairman. The committee shall be composed of the present Chairman, the Past-Chairman, two other members of the Board of Managers not up for election, and three other voting members of the Section not currently officers or managers of the Section. Nominations shall be made by a three-quarters affirmative vote of the total Nominating Committee. Such nominations shall be final, unless any nominee is rejected by a three-quarters vote of the Board of Managers, and in the event of such rejection the Board of Managers will make its own nomination.

The Chairman of the Section shall then notify the candidates of their nomination. From the list of acceptances, not more than three names for each vacancy shall be selected by the Board of Managers and placed on a letter ballot. A blank space shall be provided on this letter ballot under each office, in which space the name of any voting member other than those suggested by the Board of Managers may be voted for. The balloting shall then take place. The ballot shall be enclosed with a blank envelope and a business reply envelope bearing the local Secretary-Treasurer's address and a space for the member's name and address. One of these shall be mailed to each voting member of the Society residing in the geographical area covered by the Section, not less than forty days in advance of the annual fall convention.

The voter shall then indicate on the ballot one choice for each office, seal the ballot in the blank envelope, place this in the envelope addressed to the Secretary-Treasurer, sign his name and address on the latter, and mail it in accordance with the instructions printed on the ballot. No marks of any kind except those above prescribed shall be placed upon the ballots or envelopes. Voting shall close seven days before the opening session of the annual fall convention. The sealed envelopes shall be delivered by the Secretary-Treasurer to his Board of Managers at a

duly called meeting. The Board of Managers shall then examine the returned envelopes, open and count the ballots, and announce the results of the election.

The newly-elected officers and managers shall take office on January 1, following their election.

SECTION BUSINESS

Sec. 7. The business of a Section shall be conducted by the Board of Managers.

SECTION EXPENSES

Sec. 8. (a) At the beginning of each fiscal year, the Secretary-Treasurer of each section shall submit to the Board of Governors of the Society a budget of expenses for the year.

(b) The Treasurer of the Society shall deposit with each Section Secretary-Treasurer a sum of money for current expenses, the amount to be fixed by the Board of Governors.

(c) The Secretary-Treasurer of each Section shall send to the Treasurer of the Society, quarterly or on demand, an itemized account of all expenditures incurred during the preceding period.

(d) Expenses other than those enumerated in the budget, as approved by the Board of Governors of the Society, shall not be payable from the general funds of the Society without express permission from the Board of Governors.

(e) The Section Board of Managers shall defray all expenses of the Section not provided for by the Board of Governors, from funds raised locally.

(f) The Secretary of the Society shall, unless otherwise arranged, supply to each Section all stationery and printing necessary for the conduct of its business.

SECTION MEETINGS

Sec. 9. The regular meetings of a Section shall be held in such places and at such hours as the Board of Managers may designate. The Secretary-Treasurer of each Section shall forward to the Secretary of the Society, not later than five days after a meeting of a Section, a statement of the attendance and of the business transacted.

CONSTITUTION AND BYLAWS

Sec. 10. Sections shall abide by the Constitution and Bylaws of the Society and conform to the regulations of the Board of Governors. The conduct of Sections shall always be in conformity with the general policy of the Society as fixed by the Board of Governors.

BYLAW XII

STUDENT CHAPTERS

Sec. 1. Student Chapters of the Society may be authorized in any college, university, or technical institute of collegiate standing. Upon written petition for the authorization of a Student Chapter, signed by twelve or more Society members, or applicants for Society membership, and the Faculty Adviser, the Board of Governors may grant such authorization.

CHAPTER MEMBERSHIP

Sec. 2. All members of the Society in good standing who are attending the designated educational institution shall be eligible for membership in the Student Chapter, and when so enrolled they shall be entitled to all privileges that such Student Chapter may, under the Constitution and Bylaws, provide.

Sec. 3. Should the membership of the Student Chapter fall below ten, or the average attendance at meetings not warrant the expense of maintaining the organization, the Board of Governors may cancel its authorization.

CHAPTER OFFICERS

Sec. 4. The officers of each Student Chapter shall be a Chairman and a Secretary-Treasurer. Each Chapter officer shall hold office for one year, or until his successor is chosen. Where possible, officers shall be chosen in May to take office at the beginning of the following school year. The procedure for holding elections shall be prescribed in Administrative Practices.

FACULTY ADVISER

Sec. 5. A member of the faculty of the same educational institution shall be designated by the Board of Governors as Faculty Adviser. It shall be his duty to advise the officers on the conduct of the Chapter and to approve all reports to the Secretary and the Treasurer of the Society.

CHAPTER EXPENSES

Sec. 6. The Treasurer of the Society shall deposit with each Chapter Secretary-Treasurer a sum of money, the amount to be fixed by the Board of Governors. The Secretary-Treasurer of the Chapter shall send to the Treasurer of the Society at the

end of each school year or on demand an itemized account of all expenditures incurred.

CHAPTER MEETINGS

Sec. 7. The Chapter shall hold at least four meetings per year. The Secretary-Treasurer shall forward to the Secretary of the Society at the end of each school year a report of the meetings for that year, giving the subject, speaker, and approximate attendance for each meeting.

BYLAW XIII

AMENDMENTS

Sec. 1. Proposed amendments to these Bylaws may be initiated by the Board of Governors or by a recommendation to the Board of Governors signed by ten voting members. Proposed amendments may be approved at any regular meeting of the Society at which a quorum is present, by the affirmative vote of two-thirds of the members present and eligible to vote thereon. Such proposed amendments shall have been published in the *Journal* of the Society, in the issue next preceding the date of the stated business meeting of the Society at which the amendment or amendments are to be acted upon.

Sec. 2. In the event that no quorum of the voting members is present at the time of the meeting referred to in Sec. 1, the amendment or amendments shall be referred for action to the Board of Governors. The proposed amendment or amendments then become a part of the Bylaws upon receiving the affirmative vote of three-quarters of the entire membership of the Board of Governors.

16-Mm Sound Service Test Film

USERS AND MANUFACTURERS of 16-mm sound projectors have long had available a comprehensive group of sound test films produced and sold by the Society and the Motion Picture Research Council. Although distribution of these films was not restricted, but on the contrary has been encouraged widely, the order of technical accuracy demanded by the specifications under which they were made forced production costs up so high that their use was, in effect, restricted to professional applications.

Realizing that there was a tremendous need for a more practical type of sound test film, combining on one reel several tests having an order of accuracy commensurate with the test equipment and tools in use by projector service men, the Society set about developing such a film. The result is the recently announced 16-Mm Sound Service Test Film. It includes technical test sections that check the lateral position of the film as it passes the sound scanning beam, the focus of the sound reproducer optical system and the over-all frequency-response characteristic of the projector. There are also three music samples, and one section of dialogue that provide a critical over-all listening test. Together, these several sections will show whether or not poor sound performance is the fault of the projector, and if so, the nature of the trouble being encountered.

Individual projector owners, schools, churches and service shops may now perform a specific series of tests, and by following the instructions that appear on the screen, interpret the test results in terms of repairs or adjustments needed to put the equipment back in good order.

TITLE MUSIC. The title music is a specially recorded orchestral section selected as a subjective test of the frequency range, high- and low-frequency balance, and distortion introduced by the 16-mm projector being tested. If the sound system is correctly adjusted, this section, particularly in the ascending xylophone runs and the high-pitched bell tones, should be clear, crisp and full, without harshness and without quaver.

SOUND FOCUSING TEST. This section is for use in making a quick focus adjustment of the sound optical system and contains 15 ft of square wave, 5,000-cycle track. Maximum loudness of the tone from the loudspeaker is a sufficient indication of correct focus. If correct adjustment cannot be attained in the length of time provided using the normal focus control, it is recommended that a careful shop adjustment be made using Service Type Sound Focusing Test Film, Z22.42, which is 100 ft in length and is supplied with complete instructions for use.

BUZZ TRACK. When this section is run on the projector in correct adjustment, that is when the sound-track scanning light beam is properly positioned and the film does not weave from side to side, no tone should be heard from the loudspeaker. If the scanning beam is too near the edge of the film, a 1000-cycle tone will be audible; or if it is too far from the edge a 300-cycle tone will be heard. Adjusting the guides that position the film laterally should eliminate both tones. The tones will be heard alternately if the film is weaving from one side to the other, and they will both be heard at once if the length of the scanning beam is too great. To remedy either of the last two faults, a shop adjustment should be made using the American Standard Buzz Track Film, Z22.57.

FREQUENCY RESPONSE. This section is a subjective test which permits the listener to make a quick aural evaluation of the frequency response of the projector and its loudspeaker. There are twelve different frequencies ranging from 50 through 6,000 cycles, each of which runs for about ten seconds. A 400-cycle tone precedes the 50-cycle section and also follows the 6,000-cycle section, as a volume-level check.

During reproduction of the first section, the tone control should be set at normal and the volume control adjusted for a comfortable listening level. All tones that follow should be clearly audible and none should be uncomfortably loud. If any of the foregoing conditions is not met, the projector is not operating in a satisfactory manner.

Assuming the buzz track and sound focusing section have indicated correct optical adjustment, failure to reproduce the multi-frequency section properly indicates trouble in the amplifier or associated loudspeaker system. Adjustment and repair of these components require the use of precision instruments and a carefully calibrated multi-frequency test film made in accordance with American Standard, Z22.44.

DIALOGUE. This section is included as an example of good dialogue recording. Sibilants should be clear and crisp, while low tones should be full. With the loudspeaker placed near or directly behind the screen there should be a definite feeling of "presence."

PIANO MUSIC. When this section is correctly reproduced it should give the reverberant effect of being played in a "live" room. The full tonal range should reproduce well, particularly without appreciable waver of sustained notes. Failure to meet this latter requirement indicates varying rate of motion as the film passes the sound scanning beam and the projector should be checked using American Standard 3,000-Cycle Flutter Test Film, Z22.43.

ORCHESTRAL MUSIC. This section should give the effect of being played in a large auditorium having a slight reverberation characteristic. The orchestra should sound well balanced and the volume range should be handled by the projector without the necessity for changing the adjustment of the volume controls. High-level passages should reproduce without distortion while the low-level portions should be clearly audible.

teristics. This latter group assembled the necessary
questionnaire that was submitted to all known color
sents its findings here in tabular form.
hile all processes listed can produce release prints with
osition as defined in American Standards Z22.3–1946
16-mm), in commercial practice some of them do not.
sal processes, when used to make release prints on re-
t printing from reversal originals.
es to express its appreciation to the manufacturers
nted, for their co-operation in this survey.

Subcommittee on

Color Film Sound Track Characteristics

L. T. Goldsmith, *Chairman*

A. C. Blaney — J. G. Frayne
R. O. Drew — G. C. Misener

January 3, 1950

Reproduction Characteristics				Density or Area Track Preferred	
Ultraviolet	"Red" Phototube	"Blue" Phototube	Lead Sulfide Tube		
					35-MM FILM
..... film tracks.	Preferred	Should be satisfactory	No information	Either	*Agfacolor*
.....	Satisfactory	No information	No information	Either	*Americolor*
No information	Preferred	For dye track only	Not tested	Either	*Ansco Color*
Moderate	Preferred	Usable	Requires further study	No preference	*Cinecolor*
.....	Normal black-and-white	Normal black-and-white	Normal black-and-white	Either	*Dufaychrome*
t higher trans-	Suitable[1]	Suitable[1]	Suitable[1]	Either[1]	*Dufaycolor*
Little	For metallic plus dye	For dye track only	For metallic plus dye	No preference	*Du Pont Release 225*
Maximum	No preference[2]	No preference[2]	No preference[2]	No preference[2]	*Polacolor*
.....	Normal black-and-white	Normal black-and-white	Normal black-and-white	Either	*Technicolor*
Some transmission	Preferred	Usable	Usable	Either, variable area preferred	*Trucolor*
					16-MM FILM
No information	Preferred	Not recommended	No information	Either	*Ansco Color*
No information	Preferred	Not recommended	No information	Either	*Kodachrome*
Moderate	Preferred	Usable	Requires further investigation	No preference	*Cinecolor*
.....	Normal black-and-white[3]	Normal black-and-white[3]	Normal black-and-white[3]	Either[3]	*Dufaychrome*
Moderate	Preferred[4]	Usable[4]	Not recommended[4]	Either[4]	*Technicolor, "A" Process*
Large	Preferred[5]	Not recommended [5]	Excellent response[5]	Variable area[5]	*Technicolor "B" Process*

white silver track.
e as for black-and-white.

[4] Track is similar to Eastman 16-mm Kodachrome.
[5] Track is used on Technicolor 16-mm Inbibition prints.

Characteristics of Color Film Sound Tracks

A Report of the SMPTE Color Committee

DURING A TWO-YEAR PERIOD from 1948 through 1949, the Society and individual equipment designers studied extensively the possible use of blue-sensitive phototubes and lead-sulfide photocells for sound reproduction, but specific conclusions could not be reached.

One effective obstacle to the study was the dearth of information about the appearance, behavior and physical characteristics of the several 35- color film sound tracks that were likely to be encountered in com tions.

The Society's Color Committee, under the Chairmanship of D was asked to help in this work and accordingly appointed a Subcom

	Manufacturer		Product	Appearance of Track				
	Name	Address	Name	Emulsion	Base	Through	Composition	Infrared
35-MM FILM								
Agfacolor	Agfa	Wolfen, Germany	Agfacolor Positive	Yellow-brown	Blue-black	Black-and-white	Dye and silver	.....
Americolor	Color Film Co. of America	New York, N.Y.	Americolor	Opaque Blue-gray matte surface	Opaque blue-gray matte surface	Opaque blue-gray matte surface	Silver dichromate	Note: Because .....
Ansco Color	General Aniline & Film Corp., Ansco Div.	Binghamton, N.Y.	Ansco Color Printing Film Types 732 and 832	Matte surface	Glossy surface	Light amber modulated area	Silver sulfide	Moderate, with moderate to maximum modulation
Cinecolor	Cinecolor, Inc.	Burbank, Calif.	Cinecolor	Blue matte surface	Blue, glossy	Blue	Iron tone	None
Dufaychrome	Dufay-Chromex Ltd., Film Lab.	Thames Ditton, Surrey	Dufaychrome	Normal black-and-white	Normal black-and-white	Normal black-and-white	Silver	.....
Dufaycolor	Dufay-Chromex Ltd., Film Laboratories	Thames Ditton, Surrey, Eng.	Dufaycolor (additive)	Similar to black-and-white	Dark, glossy	Opaque track with colored reseau background	Silver	Sensibly uniform
Du Pont Release 225	Du Pont Photo Products Div.	Parlin, N.J.	Du Pont Color Release Positive 225 Type	Brownish red, matte	Brownish red, glossy	Brownish red	Metallic plus dye	Little
							Dye only	Maximum
Polacolor	Polaroid Corp.	Boston, Mass.	Polacolor	Silver	Silver	Magenta stain	Silver	.....
Technicolor	Technicolor Motion Pic. Corp.	Hollywood, Calif.	Technicolor 35-mm	Silver	Silver	Silver	Silver	.....
Trucolor	Consolidated Film Industries, Inc.	West Fort Lee, N.J.	Trucolor 35-mm	Normal	Normal	Blue-black	Metal plus dye	Absorbs
16-MM FILM								
Ansco Color	General Aniline & Film Corp. Ansco Div.	Binghamton, N.Y.	16-mm Ansco Color Duplicating Film Type 232	Matte surface	Glossy surface	Brownish	Silver sulfide	Moderate, moderate to maximum modulation
Kodachrome	Eastman Kodak Co.	Rochester, N.Y.	16-mm Kodachrome Type 5265	Semi-matte	Glossy	Brownish	Nearly pure silver sulfide	Moderate, moderate modulation
Cinecolor	Cinecolor, Inc.	Burbank, Calif.	Cinecolor, 16-mm	Blue matte surface	Blue, glossy	Blue	Iron tone	None
Dufaychrome	Dufay-Chrome Ltd., Film Lab.	Thames Ditton, Surrey	Dufaychrome 16-mm	Normal black-and-white	Normal black-and-white	Normal black-and-white	Silver	.....
Technicolor, "A" Process	Technicolor Motion Picture Corp.	Hollywood, Calif.	Technicolor 16-mm, "A" Process	Black matte	Black, glossy	Black	Silver iodide plus dye	Little
Technicolor, "B" Process	Technicolor Motion Picture Corp.	Hollywood, Calif.	Technicolor 16-mm, "B" Process	Blue, glossy	Blue, glossy	Blue	.....	Little

[1] The reseau background is so fine that no audible whistle results, or the whistle has very low level if the cell has a uniform sensitivity. In practice the recording level is raised slightly or the fader setting increased 1 or 2 p reseau density.

ral 35-mm and 16-mm
n commercial applica-

of Dr. H. H. Duerr,
ubcommittee on Color

Film Sound Track Characteristics. This latter group assembled the necessary basic information through a questionnaire that was submitted to all known color film manufacturers and presents its findings here in tabular form.

It should be noted that while all processes listed can produce release prints with emulsion in the standard position as defined in American Standards Z22.3–1946 (35-mm) and Z22.16–1947 (16-mm), in commercial practice some of them do not. These are the 16-mm reversal processes, when used to make release prints on reversal print stock by contact printing from reversal originals.

The Subcommittee wishes to express its appreciation to the manufacturers whose products are represented, for their co-operation in this survey.

Subcommittee on
Color Film Sound Track Characteristics
L. T. Goldsmith, *Chairman*
A. C. Blaney — J. G. Frayne
R. O. Drew — G. C. Misener

January 3, 1950

Relative Transmission to				Reproduction Characteristics			Density or Area Track Preferred	
Red	Green	Blue	Ultraviolet	"Red" Phototube	"Blue" Phototube	Lead Sulfide Tube		
								35-MM FILM
.....No information.....				Preferred	Should be satisfactory	No information	Either	*Agfacolor*
cause of silver content, should resemble black-and-white film tracks.								
.....No information.....				Satisfactory	No information	No information	Either	*Americolor*
th Moderate, with maximum modulation	Little, with moderate modulation	Little, with moderate modulation	No information	Preferred	For dye track only	Not tested	Either	*Ansco Color*
None	Moderate to maximum	Moderate to maximum	Moderate	Preferred	Usable	Requires further study	No preference	*Cinecolor*
.....Same as black-and-white.....				Normal black-and-white	Normal black-and-white	Normal black-and-white	Either	*Dufaychrome*
orm transmission in the visible spectrum; somewhat higher transmission in the ultraviolet and infrared.				Suitable[1]	Suitable[1]	Suitable[1]	Either[1]	*Dufaycolor*
Little	Little	Little	Little	For metallic plus dye	For dye track only	For metallic plus dye	No preference	*Du Pont Release 225*
Moderate	Little	Little	Maximum					
.....Same as black-and-white.....				No preference[2]	No preference[2]	No preference[2]	No preference[2]	*Polacolor*
.....Same as black-and-white.....				Normal black-and-white	Normal black-and-white	Normal black-and-white	Either	*Technicolor*
Absorbs	Some transmission	Some transmission	Some transmission	Preferred	Usable	Usable	Either, variable area preferred	*Trucolor*
								16-MM FILM
Moderate, maximum modulation	Little, moderate modulation	Little, moderate modulation	No information	Preferred	Not recommended	No information	Either	*Ansco Color*
Moderate, maximum modulation	Little, maximum modulation	Little, moderate modulation	No information	Preferred	Not recommended	No information	Either	*Kodachrome*
None	Moderate to maximum	Moderate to maximum	Moderate	Preferred	Usable	Requires further investigation	No preference	*Cinecolor*
.....Same as black-and-white.....				Normal black-and-white[3]	Normal black-and-white[3]	Normal black-and-white[3]	Either[3]	*Dufaychrome*
Moderate	Moderate	Moderate	Moderate	Preferred[4]	Usable[4]	Not recommended[4]	Either[4]	*Technicolor, "A" Process*
Little	Moderate	Large	Large	Preferred[5]	Not recommended[5]	Excellent response[5]	Variable area[5]	*Technicolor "B" Process*

2 points to offset the

[2] Normal black-and-white silver track.
[3] Track is silver, same as for black-and-white.
[4] Track is similar to Eastman 16-mm Kodachrome.
[5] Track is used on Technicolor 16-mm Inbibition prints.

67th Semiannual Convention

To bring yourself and your company up to date on the technical trends in motion pictures and television, you can do nothing better than attend the 67th Convention of the Society that will be held at The Drake hotel in Chicago from April 24 to 28.

In ten technical sessions, to be held two each day from Monday through Friday, you will hear papers on many subjects including, among others, projection arc lamps, production techniques for television studios, high-speed photography and color. You will also be invited to take part in the informal discussions that follow the presentation of all papers.

HOTEL RESERVATIONS: Rooms have been set aside for all members and their friends who wish to attend. Mr. John Gorte, Office Manager, The Drake, Chicago 11, Ill., will confirm your accommodations promptly if you will mail him the room reservation card you received during the first week of March. If you haven't mailed it, do so without delay to be certain of your accommodations in advance.

TRAVEL: Arrange for your train or plane reservations both to and from Chicago well ahead of time, because week-end travel is particularly heavy in and around Chicago. Your local travel agent will be glad to schedule your trip at least one month in advance.

CONVENTION REGISTRATION: Registration will begin at 9:30 Monday morning, April 24, in the hotel's French Room Foyer. The Registration Desk will remain open during all technical sessions, with luncheon and banquet tickets available from either E. R. Geib or W. C. Kunzmann.

LUNCHEON: A prominent speaker will address the 'Get-Together' Luncheon, scheduled for 12:30 Monday, April 24, in the hotel's Gold Coast Room. To assure seating, tickets should be purchased in advance, and table reservations must also be made with Mr. Kunzmann as early as possible. If you have special requirements, it would be well for you to write him at: National Carbon Division, Box 6087, Cleveland, 1, Ohio.

BUSINESS SESSION: Immediately following the luncheon, all the Society's Voting Members will be asked to attend an official Business Meeting of the Society in the Grand Ballroom to discuss and vote on the proposed new Society Bylaws that are published on p. 367 of this JOURNAL. This is the only business scheduled for the meeting, and since voting doubtless will be concluded promptly, the first technical papers of the Convention will be presented without delay.

COCKTAIL HOUR AND BANQUET: Wednesday evening is the time for frivolity. Bill Kunzmann will serve as host to all members and guests at the Cocktail Party which begins at 6:45 in the French Room and the informal banquet scheduled to start at 8:00 o'clock in the Gold Coast Room. There will be music, dancing,

entertainment and fun for all. Tickets for the banquet should be purchased early. Table reservations must be made with Mr. Kunzmann at the Registration Desk before Wednesday so that members may be assured of places for themselves and their guests.

LADIES' ACTIVITIES: For the wives and guests of members who plan to be in Chicago during convention week, Mrs. G. W. Colburn, Convention Hostess, and the members of the Ladies' Reception Committee have arranged a program that will prove to be both interesting and entertaining. The details of these plans will be discussed at the Ladies' Registration Headquarters in Parlor H by members of the Ladies' Reception Committee, who will be on hand daily.

RECREATION: Members and their guests who register will receive complimentary passes for the week to several de luxe motion picture theaters in Chicago. Chicago has much to offer in the way of places of historical interest and other attractions that will be described at the Registration Desk.

PLAN TO ATTEND: Bring your friends and make a successful week of this – the 67th Semiannual Convention.

Society Announcements

Student Chapter

The Student Chapter of the Society at New York University was formally established by action of the Board of Governors on January 31, 1950. This is the second Student Chapter. The first was organized at the University of Southern California and is presently under the Chairmanship of Algernon Walker.

Formation of a New York University Chapter was first proposed to the Society on November 9, 1949, by William F. Boden, a student in the Motion Picture Dept., representing 15 applicants for Student membership. Subsequently, they petitioned the Board of Governors for authorization to form a Student Chapter within the limitations established under the Bylaws of the Society.

After duly considering the petition, which had been endorsed by Professor Robert Gessner, Chairman of NYU's Motion Picture Dept., the Board of Governors voted to authorize formation of the Chapter, and extended to all Chapter members its enthusiastic welcome.

The Chapter Officers are: William F. Boden, Chairman; Gerald I. Rosenfeld, Secretary-Treasurer; and Professor Gessner, Faculty Adviser.

New Sustaining Members

The Society is always pleased to welcome additions to its list of Sustaining Members. Each new one who joins provides additional financial support needed to help carry out the many projects assigned to engineering committees and to continue the ambitious publications program being undertaken. In addition, the continued increase of sustaining support is a measure of proof that the Society's contributions to the fields that lie within the area of its technical scope are both valid and effective.

The Society is pleased to acknowledge these Sustaining Memberships, received during the past month: Blumenfeld Theaters, DuArt Film Laboratories, Inc., Hallen Corp., National Screen Service and Producers Service Co.

Film Decomposition Tests

In the paper that begins on p. 268 of this JOURNAL, Cummings Hutton and Silfin point out the serious losses that may result from decomposition in storage of cellulose nitrate motion picture film. Much of this potential loss could no doubt be avoided if a reliable test for future storage life were applied to films now being stored for commercial and archival purposes. No such test is now used regularly in the United States, but recently the attention of film librarians has been directed to two such tests developed in England, under the auspices of the British Government's Chemical Research and Development Establishment and the Department of the Government Chemist. In Report No. 2/R/48, "The Surveillance of Cinematograph Record Film During Storage," by G. L. Hutchison, L. Ellis, and S. A. Ashmore, the authors described a rather extensive investigation of the stability of film in storage and outlined the details of two test procedures which they have found useful. Further information concerning the use of these tests and the results obtained may be secured from the British Film Institute, 164 Shaftesbury, London, England. This is a government department similar to the U.S. National Archives.

So that the SMPTE's Preservation of Film Committee may have the benefit of a number of points of view concerning both the value of such tests generally and the advisability of further committee study in this direction, a brief summary of this British Report and an outline of the test methods are described immediately below. Comments and recommendations should be addressed to James W. Cummings, Chairman, SMPTE Preservation of Film Committee, The National Archives, Washington 25, D.C.

SUMMARY

"The deterioration of nitrocellulose base cinematograph film on prolonged storage is brought about by a slow but progressive decomposition of the nitrocellulose. The changes occurring are complex but it seems clear that the gelatine on the film acts as a stabilizer and accordingly suffers deterioration which involves loss of the contained silver image at about the same time that the film becomes sticky. This stage is the end of the useful life of the film, and as such film cannot be duplicated it represents a total loss of record.

"Two tests, based on methods of known value in the examination of nitrocellulose explosives, have been developed whereby it is possible to anticipate the end of the useful life of a film. The results of these tests allow sufficient time for a film to be duplicated while still in good physical condition.

"Using the two tests referred to in the above paragraph a scheme of surveillance and sentencing of stored films has been devised.

"Since the useful life of a film is well ended before conditions favorable to spontaneous inflammation arise, it is clear that danger from this source can now be avoided.

"The results of this investigation are clearly applicable in principle to all stored cinematograph film having a cellulose nitrate base."

Two recommended tests for predicting the future condition of nitrate film in storage are the Alizarin Red Heat Test and the Micro-Crucible Test. These are described briefly below:

ALIZARIN RED HEAT TEST

In this test a small punching of the film of approximately 6 mm diameter and weighing 7 mg is heated in a glass tube in which is suspended an alizarin red test paper moistened with a solution of glycerine in water. The tube is heated at a temperature of 134 C and the time noted for the development of acid vapors as indicated by a color change in the test paper.

1. Apparatus

(a) Glass tube closed at one end and approximately 90 mm in length and 9 mm internal diameter is fitted with a stopper 60 mm in length and of such a diameter that when covered with one thickness of test papers makes a close sliding fit in the tube. 45 mm of the stopper should then be in the tube.

(b) A cylindrical double-walled copper air bath, 100 mm deep and 100 mm in diameter. The metal lid is lagged with asbestos composition 8 mm thick and contains a central hole to take a thermometer and six holes, of 12-mm diameter, suitably arranged to take six testing tubes. The outer jacket of the bath is fitted with a reflux condenser.

(c) A supply of rubber rings to give convenient support to the tubes in the air bath.

(d) A supply of large size filter papers (Whatman, No. 2).

2. Preparation of the Test Paper

This is conveniently prepared by impregnating a sheet of filter paper with a 0.1% solution of alizarin red indicator in water to which has been added 2 ml of 2 *N* ammonia per 100 ml. The solution is allowed to drain off and the edges of the paper are subsequently discarded. The paper may then be air dried but should be further heated for 10 min in the steam oven before use, to drive off any traces of free ammonia.

3. Method

The outer jacket of the bath is charged with about 20 ml of pure xylene and heat is applied by means of a small gas burner. When temperature conditions are steady the thermometer should read 134 C.

In the meantime six tubes, as described at (a) under Apparatus, are prepared for test. Into each is placed a punching of the film under test, the punching being 6 mm in diameter and weighing about 7 mg. A strip of test paper is cut to such a width that when wrapped around the stopper the whole of the latter is effectively covered without any overlap which would spoil the snug fit in the tube. The test paper is then moistened with a 50% solution of glycerine in water. Each tube is fitted with a rubber ring, the position of which is adjusted so that the part of the tube contain-

ing the test paper is wholly outside the bath.

With all tubes in position in the bath the temperature and time are noted. The tubes are kept under constant observation, if necessary for rather more than one hour.

The color of the test paper prepared as described is maroon, which, in the presence of acid vapors, is either bleached or becomes a pale yellow. The change is well marked and readily observed: for the purposes of this test, the time in minutes required for a positive result is taken when the lower edge of the paper is bleached or changed in color to a distance of approximately $\frac{1}{8}$ in.

Note 1. The apparatus described can suitably be increased in size so that more than six samples can be tested at one time.

Note 2. If a tube is removed after test while the other tubes are in position, the vacant hole must be closed with a cork or bung.

MICRO-CRUCIBLE TEST

This test involves the determination of the loss in weight of a punching of cinema film when heated in a small porcelain crucible in a ventilated oven maintained at 100 C.

The crucibles are of 1 ml capacity and are obtainable from Royal Worcester Porcelain Co., or indirectly through laboratory supply firms.

A disc of film of approximately 0.25-in. diameter and weight about 7 mg is punched out of the film in question and transferred to the crucible weighed to the nearest 0.01 mg. The combined weight of crucible and film is then determined accurately, also to 0.01 mg, and the weight of film found by difference.

The crucible and film are then heated in a ventilated oven maintained at 100 C and the combined weight determined at 168 hr and 300 hr. The loss in weight is then calculated as a percentage on the original weight of the film.

RESULTS

Alizarin Red Heat Test	*Micro-Crucible Test* (after 168 hr)	*SENTENCE* *Retest after:*
60 min and over	—	2 yr
Under 60 min but not under 30 min	—	1 yr
Under 30 min but not under 10 min	Under 10%	6 months
	10% and over	Copy and destroy
Under 10 min	—	Copy and destroy

Meetings of Other Societies

Institute of Radio Engineers, Cincinnati Section, Spring Technical Conference on Television, April 29, Cincinnati, Ohio

Institute of Radio Engineers, Technical Conference, May 3–5, Dayton, Ohio

Armed Forces Communications Assn., Annual Meeting,
May 12, New York, and Long Island City
May 13, Fort Monmouth, N.J.

Acoustical Society of America, Spring Meeting, June 22–24, State College, Pa.

Illuminating Engineering Society, National Technical Conference,
August 21–25, Pasadena, Calif.

Engineering Committees

Theater Television

On February 14, the Society transmitted to the Federal Communications Commission a formal reply to the Commission's Public Notice of January 11 which outlined its plans for a hearing on allocations and rule making for a theater television service. The ten points at issue in the present controversy, as stated by the Commission, were published on p. 237 of the February JOURNAL. The Society's reply read as follows:

"Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington 25, D.C.

"In the Matter of

Allocation of Frequencies and Promulgation of Rules and Regulations for a Theater Television Service — Docket No. 9552

NOTICE OF APPEARANCE

"In accordance with Provision 7 of Public Notice No. 45051 of the Federal Communications Commission, dated January 11, 1950, and dealing with a hearing on Theater Television, the Society of Motion Picture and Television Engineers hereby files its written appearance in this proceeding, and gives notice that it will appear through its appointed representatives. They will present evidence on the issues specified in the aforementioned notice of hearing issued by the Commission upon such data, and at such time and place as may be selected by the Commission

"Submitted for the Society of Motion Picture and Television Engineers by

(Signed) E. I. SPONABLE
President"

Color

The commercial success over the last ten years of a number of different processes for motion picture release printing in color has been a substantial boon to the industry but has simultaneously introduced several very practical problems that will undoubtedly remain with us for some time to come. Limited familiarity with the language of color as a general branch of physics or as a highly specialized branch of motion picture engineering is an obstacle to many engineers and technicians who encounter these color systems in their daily work. In research or film processing laboratories where the nomenclature is better understood, the lack of uniform methods of measurement or specification complicates the already difficult problem of drawing significant comparisons between competitive processes. Commercial applications which involve the use of more than one manufacturer's product at succeeding steps in the complete process are made exceedingly complex and for the same reason the recording, duplicating and reproducing of photographic sound tracks on color films are made many times more difficult than is the case with familiar black-and-white emulsions.

To shed some additional light on this latter problem, a Color Subcommittee, under the Chairmanship of Lloyd T. Goldsmith, has prepared a tabulation of the characteristics of sound tracks produced on commercial 35- and 16-mm color print processes. The table appears on p. 377 of this JOURNAL.

Not only manufacturers and users of sound reproducing equipment, but also film laboratory technicians will find this table of real value. Reprint copies on heavy paper have been prepared and will be supplied free of charge by the Society to all who wish them. Requests for copies or comments on the tabulation should be addressed to Bill Deacy at Society Headquarters.

An early issue of the JOURNAL will carry a more extensive contribution to the available literature on color motion pictures. This will be in the form of a report on the "Principles of Color Sensitometry," prepared by the Color Sensitometry Subcommittee under the Chairmanship of Carl F. J. Overhage. This report, which has been in work for nearly a year, is now completed and in manuscript form it amounts to nearly 150 pp.

Film Dimensions

Methods of producing 16-mm release prints in large quantity through the use of 32-mm perforated films have been adopted widely in the United States during the last decade. Experience gained over this period has resulted in the gradual development of uniform practices in preparation of negative picture and sound material, in printing the release positives and in slitting after processing to produce the 16-mm prints for projection. Work was begun in 1948 on standards for the special films thus used. Formal proposals for the standardization of two 32-mm films and one 35-mm film, 32-mm perforated, were published for a period of trial and criticism in the February, 1949, JOURNAL. Shortly after publication, a question arose concerning commercial slitting tolerances of 32-mm raw stock but on further investigation raw stock was found to be within the limits published in the proposed standards. As a result objections to the original proposals were withdrawn and two of them, previously approved by the Standards Committee, have now been forwarded to the ASA Sectional Committee on Motion Pictures, Z22. The third, covering the Dimensions of 35-mm film with 32-mm perforations, had not previously been sent to the Standards Committee, so is now out for their consideration. When the action of the Standards Committee is completed, this proposal will also be submitted to the Sectional Committee.

Book Review

Introduction to Theoretical and Experimental Optics, by Joseph Valasek

Published (1949) by John Wiley and Sons, 440 Fourth Ave., New York 16. 429 pp. + 6 pp. appendix + 4 pp. "Answers to Problems" + 4 pp. bibliography + 10 pp. index. 44 illus. $5\frac{3}{8} \times 8\frac{3}{8}$ in. Price $6.50.

Publication of a new textbook of optics is a rather rare event these days when general attention is diverted to the more spectacular topics which abound in nuclear physics and electronics. A good general reason exists, therefore, to welcome this book. This is, however, not the only reason, as the book has its own

merits and it constitutes a valuable contribution to the fundamental optical literature.

The purpose of this book is to give the college student a working knowledge of the extended field of optics. Accordingly, the text covers in its four parts geometrical optics, physical optics, radiation and spectra, and a series of laboratory experiments under the heading of experimental optics. The first three parts are divided into 21 chapters accompanied by problems.

The presentation of the subject matter is well balanced and necessarily condensed, for it would not be possible to cover all the branches of optics and some closely related subjects in one handy volume. As was noted by the author and the publishers, some subjects (X rays, photographic optics, and ophthalmic lenses) are treated in greater detail than is customary in general textbooks of optics. This deviation from the usual is not objectionable to the reviewer. Although the reviewer cannot offer definitive rules as to what should be included and what may be excluded from a college textbook, he feels that no textbook should ignore the phenomena and objects with which we are in practically everyday contact. Indeed, it is rather discouraging to meet students who are conversant with the Kerr, Zeeman, Raman and other "effects," but have very little to say about their own spectacles or their photographic lenses. Let us hope that Prof. Valasek's students will be well acquainted with both laboratory and everyday aspects of optics.

Following this thought, the reviewer would have been pleased had the author at least briefly touched also the following subjects: medical and industrial radiology, biological effects of radiation, condensing and projection systems, anti-reflection films, interference filters, and phase-contrast microscopy. It is particularly difficult to justify the omission of the last three subjects which are now in the limelight of optical engineering.

The reviewer is disturbed by the fact that no recognition is given in the book to the current standardization efforts in the field of optics. Thus, while the term "equivalent focal length" has been widely used and recently sanctioned as standard by the American Standards Association (Z38.4.21—1948), it is not even mentioned in the book. It is beside the point whether or not the term is satisfactory (the reviewer is of the opinion that the "equivalent" is superfluous and misleading), as perhaps no terminology can satisfy everybody. The fact is that a strong demand exists for standardization of terms, definitions, and procedures in optics, and that a serious effort is being made, under the sponsorship of the Optical Society of America and of other organizations, to satisfy the demand. This effort will be in vain if our educational institutions do not teach the younger generation to appreciate standardization and to adhere to it. It will also be disheartening to the younger generation to discover, for example, that, while knowing the H-D speed, the Schneider number, the DIN system, and the Weston rating, they know nothing about the American Standard Speed and the American Exposure Index (Z38.2.1—1947), which are not mentioned in this book.

The book is not intended as an engineering manual. Still it may be very useful as a source of basic information to any engineering or research group concerned with optical problems. The well-selected bibliography at the end of the book adds considerably to its reference value.

Dr. K. Pestrecov
Bausch & Lomb Optical Co.
Rochester 2, N.Y.

Letter to the Editor

In "Twenty-Lens High-Speed Camera" by Charles W. Wyckoff, in the November, 1949, JOURNAL, some acknowledgments were not mentioned. The design and construction of the twenty-lens camera was carried out under the direction of Mr. Newell T. Partch who was then located at the David Taylor Model Basin. The camera itself was built at the Naval Observatory. The optical calculations were done by Dr. A. I. Mahan of the Naval Ordnance Laboratory. Mr. Wyckoff served as a consultant on the mechanical and electrical elements of the camera. Figures 6, 7 and 8 appearing in Mr. Wyckoff's paper were the result of some of the previously mentioned optical calculations. The lens chosen for this camera was not a standard Navy lens as suggested by Mr. Wyckoff. It was a simple achromatic doublet, whose characteristics were all carefully evaluated so that its performance would be known before inserting it in such a camera. Such achromatic doublets of the speed used here cannot be used at a field angle of 13° with good results. Nevertheless, this choice was made rather early to keep the cost of the first model of the camera down, with the result that the image quality deteriorated at the edge of the field even when the lens was stationary.

A. I. MAHAN
U. S. Naval Ordnance Laboratory
White Oak, Silver Spring 19, Md.

Section Meetings

Atlantic Coast

"High-Speed Motion Pictures" will be the subject of the Atlantic Coast Section Meeting, scheduled for 7:30 P.M., Wednesday, March 22, in the Western Union Auditorium at 60 Hudson St., New York City. John H. Waddell, Chairman of the Society's High-Speed Photography Committee, is to be a speaker.

Dr. Dirk Reuyl, Ballistics Research Laboratory, Aberdeen Proving Ground, Aberdeen, Md., will speak on "Optical Instrumentation for Guided Missiles."

Central

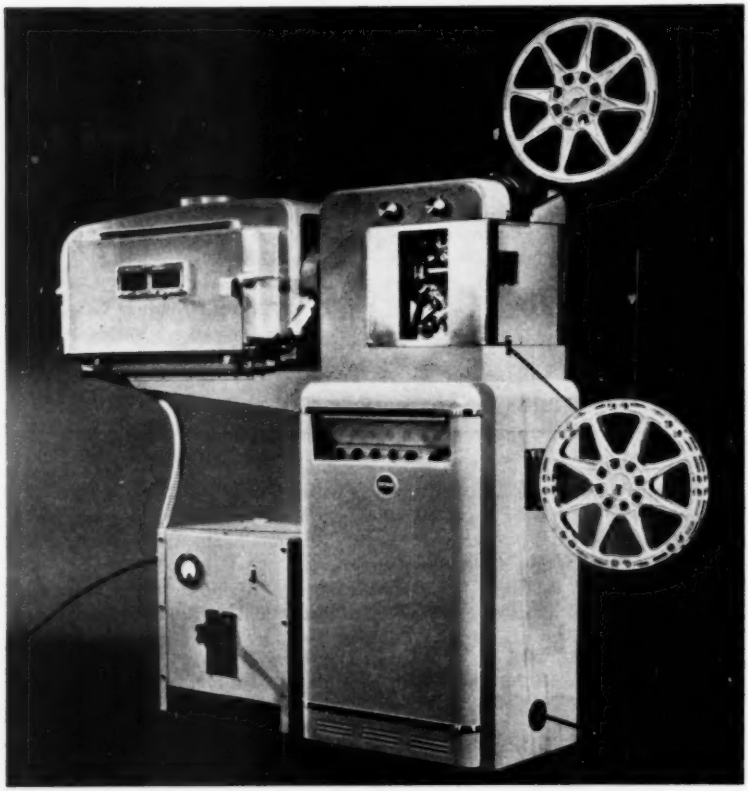
Two papers originally reported in February as being planned for presentation at the February 17th meeting of the Central Section are actually scheduled for the meeting on Thursday, March 16. The Section meets at 8:00 P.M. in the Western Society of Engineers' Auditorium, 84 East Randolph St., Chicago. The first paper is "A New Amplifier Design" by Mr. Frank McIntosh. The second paper, in two parts, describes the new DuPont Type 275 Color Release Positive Film. "Structure and Properties" will be described by Dr. A. B. Jennings, while "Printing and Processing" will be covered by Dr. J. P. Weiss.

Pacific Coast

On Tuesday, March 28, members of the Pacific Coast Section will be guests of the Eastman Kodak Company. They have been invited to attend the first 'open house' tour of the Kodachrome Cine-Processing Laboratory, 1017 No. Las Palmas Ave., Hollywood, Calif.

New Products

Further information concerning the material described below can be obtained by writing direct to the manufacturers. As in the case of technical papers, publications of these news items does not constitute endorsement of the manufacturer's statements nor of his products.



The Eastman 16-Mm Projector, Model 25, just announced by Eastman Kodak Company, has been developed to fill the need for a projector of professional caliber.

Engineered with performance and long operating life as the major design objectives, this projector introduced a number of outstanding features. An 8-frame intermittent sprocket is driven by a synchronous motor interlocked but mechanically independent of a second motor that drives the film transport sprockets and the shutter. A geneva star gives intermittent film motion but is unconventional in that it is driven through a unique two-stage acceleration movement, which increases the ratio of sprocket speed to motor speed at the moment of film pulldown. This gives extremely high acceleration of the intermittent sprocket during the work period of its operating cycle. Shutter efficiency is therefore high.

With two interruptions per frame, the shutter has a transmission of 59%. Individual motors are used to drive the film take-up and rewind reels.

Either carbon arc or 1,000-watt tungsten lamps may be used. When tungsten lamps, which burn base up, are used, a dual lamp turret allows a stand-by lamp to be moved into position in the event of a burn-out.

The sound scanning drum is driven by the film while a magnetically damped stabilizer holds the flutter content to 0.2% rms.

The projector base houses an illuminated control panel and an Altec Lansing amplifier, with tone and volume controls as well as a switch for phonograph or microphone input.

The projector is available, equipped for 115-volt, 60-cycle, a-c operation, and with either the Altec-Lansing Model 800 or the Model 604-B speaker.

"Permanent and lengthy 'on-the-spot' sound recordings" is the lead of the release accompanying this photo from the Miles Reproducer Co., Inc., 812–814 Broadway, New York 3, N.Y. The equipment is described in part as follows: The "Walkie-Recordall" weighs only 8 lb and is enclosed in an inconspicuous carrying case, measuring only 4 × 8 × 10 in., which conceals the identity of a recorder. It is designed to make permanent and continuous recordings, with a concealed microphone, of lengthy conversation of near-by and distant voices, while standing, walking or riding on trains, autos or planes.

Recording is reported to be noiseless, "thus no one is aware that conversation is being recorded," and the operator is said to need to give only the attention required to throw a silent, hidden and external switch to "On" position. It is powered by small flashlight cells and by a miniature "B" battery, both of standard type.

The manufacturer suggests that, in addition to some other, perhaps more obvious, uses "Walkie-Recordall" may be a boon in bolstering salesmen's potentialities: (1) through the aid of recorded expert sales talks to be played back to customers and (2) through reviewing and evaluating an entire day's actual conversation between a salesman and his customers.

SMPTE Officers and Committees: The names of Society Officers and of Committee Chairmen and Members are published annually in the April issue of the JOURNAL. Changes and corrections to these listings are published in the September JOURNAL.

Employment Service

POSITIONS WANTED

Project Engineer: Mechanical engineering graduate experienced in designing from specifications; optical instruments, precision cameras, mechanical servo, and gear or 3-bar computers, analytical work in stress and vibration. R. A. Barbera, 663 Ovington Ave., Brooklyn 9, N.Y.

TV and Motion Picture Engineer: 3 yr experience in motion picture engineering and research at Philips Physical Laboratories, Eindhoven; 6 yr as TV-Director, same firm; 3 yr as Director of Decca plant in Belgium. Desires assignment in any part U.S.A. Highest qualifications and references U.S. firms. Write Fernand Beguin, c/o Mr. Marc Albanese, 416 Madison Ave., New York 17.

In technical phase: Motion picture or still photography. 4 yr experience in research, development, and testing, both color and b & w films. Graduating from M.I.T. June, 1950. Member, SMPTE. W. A. Farmer, 141 Grand Ave., Rochester 9, N.Y.

Cameraman-Director: Currently employed by internationally known producer, desires greater production opportunities. Fully experienced 35- and 16-mm, color, b & w; working knowledge editing, sound, and laboratory problems; administrative experience. Top references and record of experience available. Write P.O. Box 5402, Chicago.

Cameraman: Trained with practical experience in 16-mm and 35-mm equipment & technique with prominently successful men in the industry. Thoroughly familiar with B & H Standard, Mitchell, Eyemo, & Filmo cameras, Moviolas, etc. Thorough knowledge & experience script-to-screen production technique: directing, editing, photography, film evaluation, production, treatments, shooting-scripts, small budgets, documentary & theatrical production. Go anywhere. Age 33. Top industry & character references furnished confidentially. Anxious for position where ability, sincere interest and creativeness offer opportunity. Active Member of SMPTE. Write Milton L. Kruger, R.F.D. 1, Ridgewood, N.J.

SMPTE HONOR ROLL

By action of the Board of Governors, October 4, 1931, this Honor Roll was established for the purpose of perpetuating the names of distinguished pioneers who are now deceased.

Louis Aimé Augustin Le Prince
William Friese-Greene
Thomas Alva Edison
George Eastman
Frederic Eugene Ives
Jean Acme Le Roy
C. Francis Jenkins
Eugene Augustin Lauste
William Kennedy Laurie Dickson
Edwin Stanton Porter
Herman A. DeVry
Robert W. Paul
Frank H. Richardson
Leon Gaumont
Theodore W. Case
Edward B. Craft
Samuel L. Warner
Louis Lumiere
Thomas Armat

HONORARY MEMBERS

Lee de Forest
A. S. Howell

High-speed photography is the most recent major addition to the scope of the Society's technical committees' work. Three hundred pages on the subject appeared in the *Journal* during 1949 and many more are scheduled for 1950, either written, or arranged for, by members of the Society's High-Speed Photography Committee. As a result of this extensive publication program, members have been able to follow the evolution of many new tools of scientific photography. Engineers whose interests are design and manufacture in photography, or who are in industries where photographic analysis methods are used, have learned about solutions to many unique application problems. In either case, their knowledge about the extent to which photography is used for industrial purposes has been expanded considerably.

One of the Society's aims is to extend even further the available knowledge in this rapidly expanding field. Reprinted under the title "High-Speed Photography" (Vol. 2) are the 177 pp. of technical material on the subject which appeared in the *Journal* for November 1949. Copies are available from Society Headquarters at $2.00. Please call this to the attention of your company librarian or your associates who would benefit from having this information on hand.

Sustaining Members

OF THE

SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS

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Bijou Amusement Co.
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National Theaters Amusement Co., Inc.
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Projection Optics Co., Inc.
Prudential Circuit
Radio Corporation of America, RCA Victor Division
Reeves Sound Studios, Inc.
SRT Television Studios
Technicolor Motion Picture Corp.
Terrytoons, Inc.
Theatre Holding Corp., Ltd.
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Titra Film Laboratories, Inc.
United Amusement Corp., Ltd.
Universal Pictures Co.
Victor Animatograph Corp.
Westrex Corp.
Wilding Picture Productions, Inc.